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JOURNAL OF SOUTH AFRICAN BOTANY

VOLUME 49

1983

*Published under the authority
of the*

Trustees

of the

National Botanic Gardens

of

South Africa,

Kirstenbosch,

Claremont.

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Publication dates:

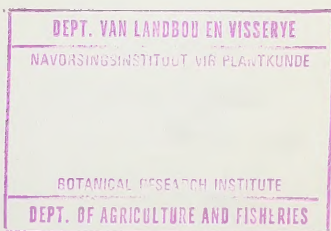
49(1): 1-86 [3 January, 1983]

49(2): 87-180 [1 April, 1983]

49(3): 181-322 [1 July, 1983]

49(4): 323-460 [12 October, 1983]

6413
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JOURNAL OF SOUTH AFRICAN BOTANY

VOLUME 49

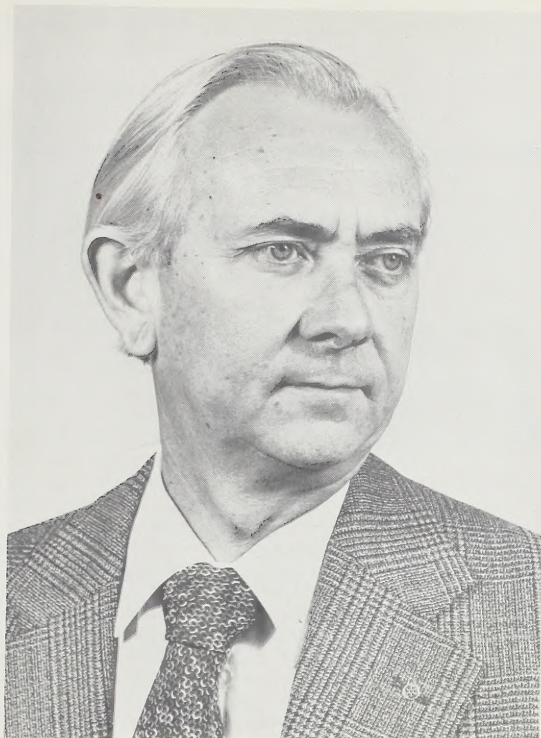
1983

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THIS VOLUME IS DEDICATED TO

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M.Sc., D.Sc. (Pret.)

(Director of the Botanical Research Institute, Pretoria)

He joined the Division of Botany and Plant Pathology in 1947 as a research assistant in charge of the grass collections of the National Herbarium, Pretoria. In 1950 he was seconded to the Royal Botanic Gardens, Kew, as South African liaison officer. In 1959 he was appointed Officer-in-Charge of Botanical Survey in Pretoria and so began a long and distinguished career in botanical administration culminating in his appointment as Director of the Botanical Research Institute in 1973. His main contributions to South African botanical literature have been revisions of the South African Ebenaceae, Stipeae, Aristideae and *Eragrostis*. In all he has collected nearly 10 000 specimens. He is commemorated in the plant names *Kirkia dewinteri*, *Aloe dewinteri*, *Aristida dewinteri*, *Silene dewinteri* and others.

He has also been active in the affairs of several scientific societies, namely the South African Association for the Advancement of Science, the South African Biological Society and the South African Association of Botanists. He has served on the Council of these societies for many years and in each case also served a term as President. He was Secretary-General of AETFAT from 1978–1982 and played a major part in the organization and ultimate success of the 10th AETFAT Congress held in Pretoria in January 1982.

TROPHIC STRUCTURE OF SOME COMMUNITIES OF FYNBOS BIRDS*

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ABSTRACT

Comparisons are made between aspects of the trophic structure of avian communities (at the alpha-diversity level) of the four major vegetation types of the fynbos biome in the south-western Cape, in order to point up some of the rôles that birds can potentially play in ecological processes in the fynbos ecosystem. More particularly, the report deals with selected features of plants as well as birds, in an attempt to evaluate the probable importance of birds as agents for either pollination or seed dispersal in fynbos vegetation.

Avian standing crop biomass and energy requirements are about five times higher in Coastal Renosterveld and Strandveld than in either Coastal or Mountain Fynbos, reflecting a major difference in the density of birds. Bird density is not unusually low in fynbos generally, in relation to some other terrestrial biome types in southern Africa, and the avifauna can be characterized as one of relatively small-bodied birds. Primary consumers account for some 50-70 % of the avian-based energy transfer in fynbos generally, and secondary and tertiary consumers are almost exclusively insectivorous. The primary consumer component is greatest in Strandveld and Coastal Renosterveld. In Mountain Fynbos the avian primary consumer component approaches or slightly exceeds 70 % apparently only in old vegetation; insectivores being relatively more prominent in younger, regenerating stands of vegetation. The production of avian food resources is allocated differently in the four main fynbos vegetation types and, concomitantly, there are trends for disproportionate increases in the relative biomass of frugivores, granivores and, to a lesser extent, folivores with an increase in total avian biomass. The nectar-eating class, however, decreases and the proportion of the insect-eating class is similar across such an arrangement. More particularly, seeds and foliage apparently are more abundantly available to birds in Strandveld and Coastal Renosterveld than in Coastal and Mountain Fynbos, and fleshy fruits are relatively abundant only in Strandveld.

Broadly speaking, seasonal cycles of vegetative growth and flowering are opposite in Strandveld and Coastal Renosterveld on the one hand, and Coastal Fynbos and low-altitude Mountain Fynbos on the other. These differences are matched very roughly by changes in the seasonal composition of the avifaunas, particularly the nectarivorous species. However, the changes in avian species composition and abundance appear to be relatively small in Strandveld and Coastal Renosterveld communities. In essence, this means that Coastal and Mountain Fynbos avian communities are more dynamic, reflecting the birds' movements in tracking spatially and temporarily fluctuating resources. The actual movements made by the birds are not well understood, and their study is needed urgently to provide the knowledge essential for proper conservation of fynbos in the south-western Cape. This applies particularly to the nectarivorous birds which apparently are important pollinators of many fynbos plants.

* Accepted for publication 10th March, 1982.

UITTREKSEL

DIE VOEDINGSAMESTELLING VAN SOMMIGE GEMEENSAPPE FYNBOS VOËLS

Vergelykings word getref tussen aspekte van voedingsamestelling van voëlgemeenskappe (by die alpha-verskeidenheid vlak) van die vier hoof-plantegroei tipes van die fynbos bioom in die suid-westelike Kaap, sodat sommige van die rolle wat voëls moontlik kan speel in die ekologiese prosesse in die fynbos ekosisteem bepaal kan word. Daar word veral gelet op geselekteerde eienskappe van plante en voëls, in 'n poging om bestuiwings- of saadverspreidingsagente in fynbos te bepaal.

Die biomassa van die voëls en hulle energiebehoefte is sowat vyf keer hoër in Kusrenosterveld en Strandveld as in beide Kus- en Bergfynbos wat op 'n groot verskil in voëlbevolking dui. Die digtheid van voëls is nie buitengewoon laag in fynbos in vergelyking met ander bioom tipes in suidelike Afrika nie en die voëlbevolking word gekenmerk deur relatief klein voëltjies. Primêre verbruikers is sowat 50 tot 70 % van die voël-energieoordrag in fynbos en sekondêre en tersiêre verbruikers is byna uitsluitlik insekvreter.

Die primêre verbruiker-komponent is die grootste in Strandveld en Kusrenosterveld. In Bergfynbos kom die primêre voël verbruiker alleen in ou fynbos naby 70 %. Insekvreter is relatief meer prominent in jonger, herstellende stande plantegroei. Die produksie van voël voedselbronne is verskillend in die vier hoof fynbos plantegroei-tipes en terselfdertyd is daar 'n neiging vir 'n oneweredige vermeerdering in die relatiewe biomassa van vrugte-, graan- en, tot 'n mindere mate, blaarvreters met 'n toename in die totale voëlbioom. Die nektaretende klas verminder en die verhouding van inseketers is insgelyk dwars met so 'n reëling. Dit is veral sade en blare wat meer gereedlik beskikbaar is vir voëls in die Strandveld en Kusrenosterveld as in die Kus- en Bergfynbos en vlesige vrugte is slegs in die Strandveld relatief volop.

In die breë gesien, is die seisoens-groeisiklusse en blomtye teenoorgesteld in die Strandveld en Kusrenosterveld aan die een kant en die Kusfynbos en lae hoogte Bergfynbos aan die anderkant. Hierdie verskil word rofweg gevolg deur die veranderinge in seisoens-samestelling van die voëlbevolking, veral die nektareters. Tog blyk veranderinge in die samestelling van die voëlbevolking en voorkoms relatief klein in die Strandveld- en Kusrenosterveld-gemeenskappe. Dit beteken in werklikheid dat Kus- en Bergfynbos-voëlgemeenskappe meer dinamies is omdat hulle bewegings tydelik fluktuierende bronne volg. Die werklike beweging van voëls word nog nie goed verstaan nie en verdere studie is noodsaaklik terwille van die behoorlike bewaring van die fynbos van die suidwes-Kaap. Dit is veral van toepassing op die nektareters wat blykbaar belangrike bestuiwers van baie fynbos plante is.

INTRODUCTION

Each of the four major vegetation types of the fynbos biome in the south-western Cape, South Africa, supports a distinct avifauna, with avian species richness in communities of Coastal Fynbos, Coastal Renosterveld and Strandveld being about double that in Mountain Fynbos (Siegfried and Crowe, 1982). Here I report on a preliminary and provisional comparison of aspects of the trophic organizations of these avifaunas, in order to point up some of the rôles that the birds potentially can play in ecological processes in the fynbos ecosystem. More particularly, I report on selected features of plants as well as birds, in an attempt to evaluate the probable importance of birds as agents for either pollination or seed dispersal in fynbos vegetation.

STUDY AREA AND METHODS

Detailed descriptions of 11 study sites (Appendix 1) representative of major vegetation types in the fynbos biome, and the methods used in surveying birds and plants in these vegetation types, are given in Siegfried and Crowe (1982). Phenological data on flowering, fruiting and vegetative growth of 10 individually-marked plants of each of the most prominent (conspicuous and/or abundant) species, in four segments along two transects, were recorded each month during at least 12 months in each of the vegetation types. The size, form and colour of the species' seeds, fruits and flowers were recorded at each of the 11 study sites. An additional study site comprising 50 ha of mature Coastal Fynbos near Hopefield (S 33° 3' E 18° 22') was censused regularly for birds, but the vegetation was not studied.

RESULTS AND DISCUSSION

Avian biomass and consumers

Avian standing crop biomass in Coastal Renosterveld and Strandveld is about five times higher than that in either Coastal or Mountain Fynbos (Table 1). The relatively high biomass in Coastal Renosterveld and Strandveld is not due to a disproportionate number of heavier species, but it is rather a reflection of denser populations of birds (Fig. 1, Table 2). Avian standing crop biomass in Coastal and Mountain Fynbos is considerably lower than that in savanna vegetation (Table 1). However, bird density is not unusually low in fynbos in relation to some other terrestrial biome types in southern Africa (Table 2). Hence, it is likely that the fynbos avifauna can be characterized as one of relatively small-bodied birds.

TABLE 1.

Bird biomass (kg/100 ha) and energy requirement (kcal/m²/y⁻¹) in savanna and fynbos vegetation in southern Africa. First approximation annual energy requirement was calculated following Tarboton (1980) and using the Lasiewski-Dawson (1967) equation. (Comparable figures for other terrestrial biome types in southern Africa are not yet available.)

Vegetation	Biomass	Energy	Source
<i>Acacia</i> Woodland, Transvaal	84,6	17,5	Tarboton (1980)
<i>Burkea</i> Woodland, Transvaal	40,7	7,5	Tarboton (1980)
Strandveld	42,6–45,6	9,6–11,2	This study
Coastal Renosterveld	45,9	10,9	This study
Coastal Fynbos	7,9–8,3	1,9–2,3	This study
Mountain Fynbos	3,1–14,1	1,9–2,7	This study

The avian communities of Strandveld and Coastal Renosterveld vegetation have energy requirements similar to that of a *Burkea* savanna avifauna (Table 1). Primary consumers account for some 50–70 % of the avian-based energy transfer in fynbos communities, and secondary and tertiary consumers are almost exclusively insectivores (Table 3). Primary consumers ap-

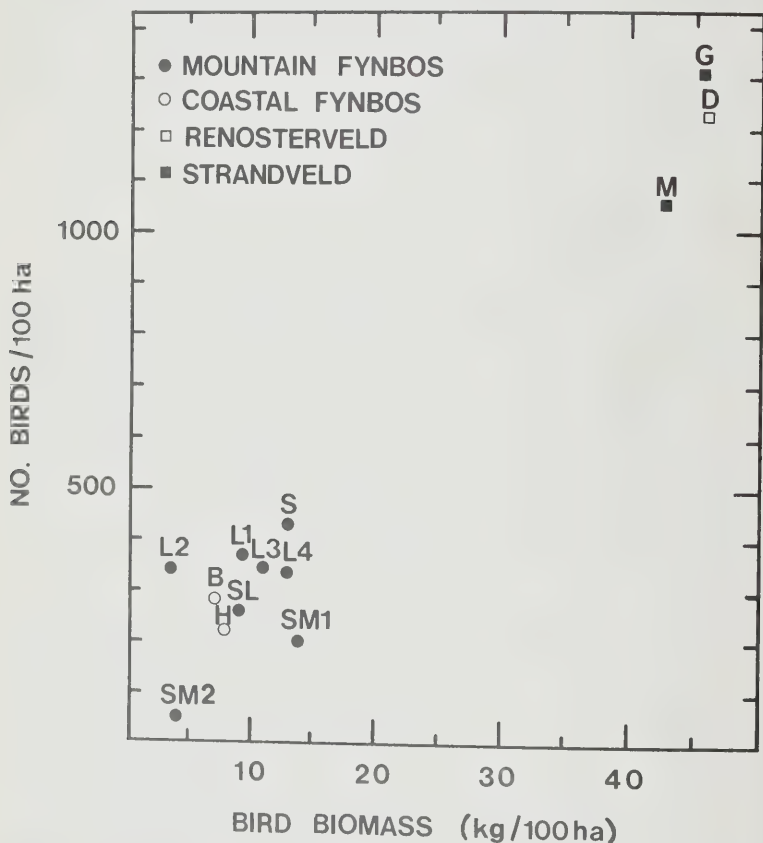


FIG. 1.

Relationship between density and standing crop biomass of birds in Mountain Fynbos (SL Sir Lowry's Pass, S Swartboschkloof, SM Silvermine, L Lebanon), Coastal Fynbos (B Barhuis, H Hopefield), Renosterveld (D De Grendel) and Strandveld (G Geelbek, M Melkbosch) vegetation types. Based on monthly mean numbers of birds censused during a full year.

parently rank lower in *Acacia* and *Burkea* savanna avifaunas; and, in the *Acacia* community ($2.3 \times$ the annual energy requirements of the *Burkea* community) they provide slightly more than 50 % of the energy transfer, whereas in *Burkea* it is the secondary and tertiary components that do so (Tarboton, 1980). Accepting that the data sets are at best first approximations, this trend is paralleled in fynbos in that the primary consumer component is greatest in Strandveld and Coastal Renosterveld which, similarly to the *Acacia* community, occur on soils relatively rich in plant nutrients (Kruger, 1979) and whose primary production is suspected to be greater than in Mountain or Coastal Fynbos. In Mountain Fynbos, at least, the primary consumer component approaches or slightly exceeds 70 %, in the avian-based energy transfer, apparently only in old vegetation; insectivores being relatively more prominent in younger, regenerating stands of vegetation.

There is a paucity of information on standing crop biomass of plant communities in the different fynbos vegetation types, and virtually nothing is

TABLE 2.
Bird density in vegetation types in southern Africa

Vegetation	No. birds/ 100 ha	Source
Valley Bushveld, eastern Cape	1 235-3 000	Winterbottom (1972)
Thorn Bushveld, eastern Cape	204	Skead (1946a)
Karroid Broken Veld, Klaarstroom	72-235	Winterbottom (1972)
Karroid Broken Veld, Robertson	764	Winterbottom (1972)
Central Upper Karoo	486	Winterbottom (1972)
Karoo, South West Africa	348	Winterbottom (1972)
Floodplain Grassland, Zambia	1 108	Winterbottom (1972)
Floodplain Grassland, Botswana	1 760	
<i>Themeda</i> Grassveld, eastern Cape	58-272	Skead (1946b)
Southern Tall Grassveld, Transkei	353	Winterbottom (1947)
<i>Cynopogon/Themeda</i> Grassveld, Lesotho	299	Winterbottom (1972)
Mopane Woodland, Zambezi Valley	1 400	Winterbottom (1956)
<i>Brachystegia</i> Woodland, Zambia	620	Winterbottom (1972)
<i>Acacia</i> Woodland, Transvaal	925-1 600	Tarboton (1980)
<i>Burkea</i> Woodland, Transvaal	399-900	Tarboton (1980)
Strandveld	1 034-1 273	This study
Coastal Renosterveld	1 230	This study
Coastal Fynbos	236-291	This study
Mountain Fynbos	200-431	This study
Fynbos	380-700	Winterbottom (1978)

TABLE 3.
Relative energy requirements of consumer classes of avian communities in fynbos vegetation in the south-western Cape. All figures are percentages

Vegetation type	Secondary and tertiary consumers		Primary consumers			
	Insectivores	Others	Nectarivores	Frugivores	Granivores	Folivores
Strandveld	28-34	1	5-6	24-25	28-36	6-8
Coastal Renosterveld	33	1	6	3	56	2
Coastal Fynbos	38-52	1	4-7	2-7	42-45	1
Mountain Fynbos	26-56	1	2-62	1	5-72	1

known about their net primary production. Nevertheless, the large difference in avian biomass between Strandveld and Coastal Renosterveld on the one hand and fynbos *sensu stricto* on the other, implies that only a relatively small fraction of the primary production in Coastal and Mountain Fynbos passes to birds and/or that primary production in these vegetation types is relatively low (Fig. 2). There are also indications that production of avian,

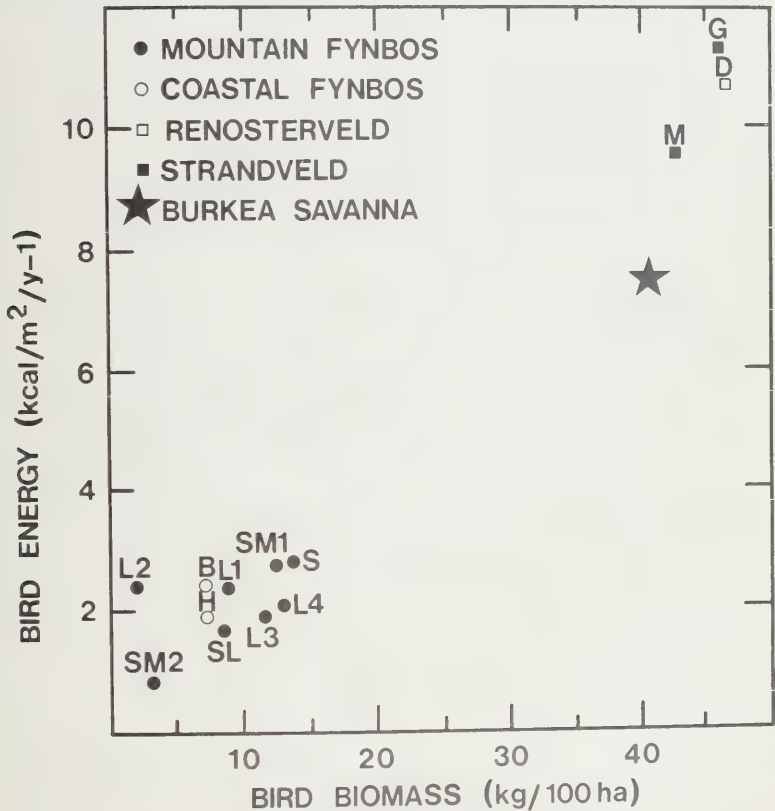


FIG. 2.

Relationship between annual energy requirements and standing crop biomass of birds in Mountain Fynbos (SL Sir Lowry's Pass, S Swartboschkloof, SM Silvermine, L Lebanon), Coastal Fynbos (B Barhuis, H Hopefield), Renosterveld (D De Grendel), Strandveld (G Geelbek, M Melkbosch) and *Burkea* savanna vegetation types. Based on monthly mean numbers of birds censused during a full year and data in Table 1.

food resources of different quality (e.g. fruits, seeds, foliage, nectar, insects, etc.) is allocated differently in the different vegetation types.

There are indications of disproportionate increases in the relative biomass of frugivores, granivores and to a much lesser extent folivores concomitant with an increase in total avian biomass, whereas the nectar-eating class decreases and the proportion of the insect-eating group is similar across a particular arrangement of vegetation types (Fig. 3). In this context, it is

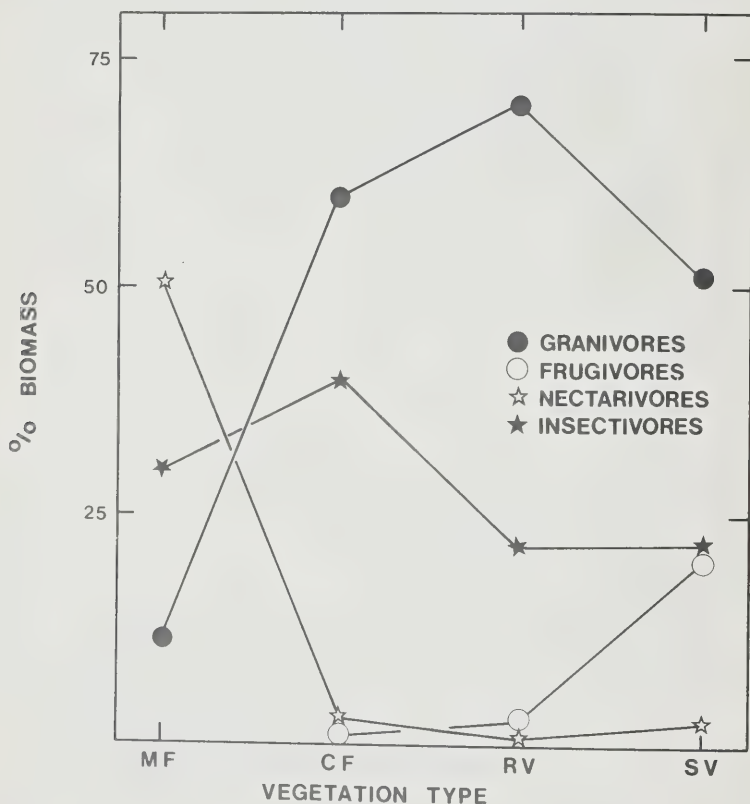


FIG. 3.
Proportionate standing crop biomass of granivorous, frugivorous, nectarivorous and insectivorous birds in Mountain Fynbos (MF), Coastal Fynbos (CF), Renosterveld (RV) and Strandveld (SV) vegetation types. Bird biomass is based on data in Appendix 2 and monthly mean numbers of birds censused during a full year.

likely that seeds and foliage are more abundantly available to birds in Strandveld and Coastal Renosterveld than in Coastal and Mountain Fynbos. Some Mountain Fynbos plant communities might produce more nectar for birds than the communities of any of the three other vegetation types, and Mountain and Coastal Fynbos tend to contain relatively high proportions of plant species which produce flowers apparently coloured so as to enhance their attractiveness to birds (Fig. 4).

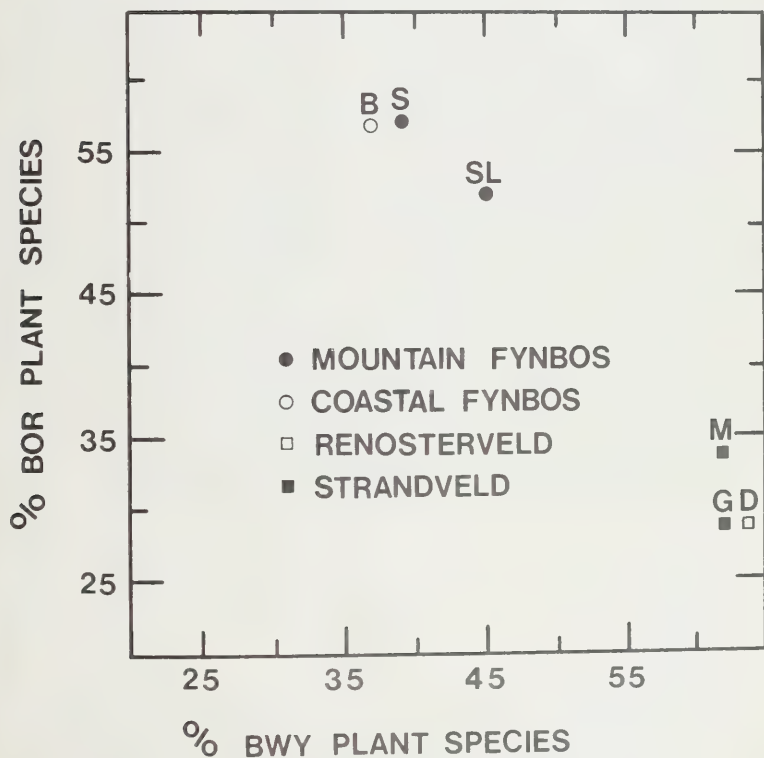


FIG. 4.

Relationship between the number of plant species having brown, orange or red (BOR) flowers and those with either blue, white or yellow (BWY) flowers in Mountain Fynbos (S Swartboschkloof, SL Sir Lowry's Pass), Coastal Fynbos (B Barhuis), Renosterveld (D De Grendel) and Strandveld (G Geelbek, M Melkbosch) vegetation types. Based on data in Appendix 3.

There are relatively few plants producing fleshy fruits in Coastal and Mountain Fynbos. Fruits of this kind are abundant only in Strandveld vegetation (Fig. 5). Species producing fleshy fruits coloured orange/red or purple/black, colours presumably attractive to birds, are poorly represented in Mountain Fynbos communities (Table 4). Large (> 10 mm) fruits are uncommon in fynbos generally, and approximately 70 % of the plant species produce small (< 3 mm) fruits mainly as achenes (Table 4). The achenes are eaten by a variety of granivorous birds (Milewski, 1978), and at least 17 es-

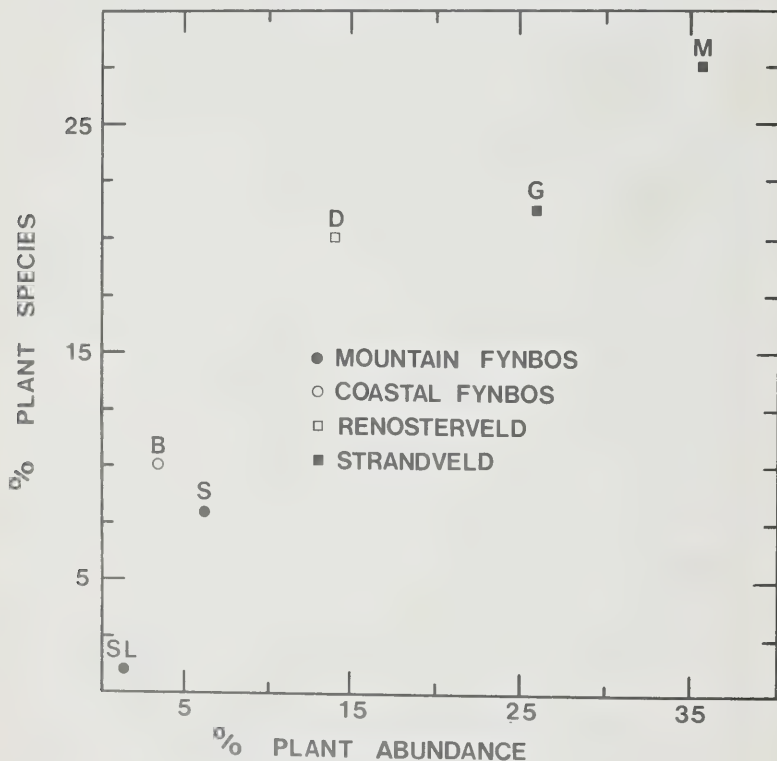


FIG. 5.

Relationship between the number of plant species producing fleshy fruits and the cover abundance (see Siegfried and Crowe, 1982) of these species in Mountain Fynbos (S Swartboschkloof, SL Sir Lowry's Pass), Coastal Fynbos (B Barhuis), Renosterveld (D De Grendel) and Strandveld (G Geelbek, M Melkbosch) vegetation types. Based on data in Appendix 3.

TABLE 4.

Percentage plant species with either small (< 3 mm), medium (3–10 mm) or large (> 10 mm) fruits, and percentage species with either orange/red or purple/black coloured fleshy fruits in fynbos vegetation in the south-western Cape. Fleshy fruits include either single-seeded or multi-seeded types; the remaining non-fleshy fruits include pods, nuts, achenes and capsules. Based on data in Appendix 3

Vegetation type and study area	Fruit size			Fleshy fruit colour		No. species sampled	Total No. species at site
	Small	Medium	Large	Orange/Red	Purple/Black		
Strandveld							
Melkbosch.....	67	29	2	13	8	60	61
Geelbek.....	72	24	1	8	6	82	85
Coastal Renosterveld							
De Grendel.....	68	24	1	10	4	74	79
Coastal Fynbos							
Barhuys.....	67	33	0	9	5	21	21
Mountain Fynbos							
Swartboschkloof.....	72	28	0	1	4	72	72
Sir Lowry's Pass.....	86	12	1	0	2	112	113
Silvermine, pre-fire.....	79	21	0	0	4	28	28
Silvermine, post-fire.....	74	25	0	0	4	52	53
Lebanon 1.....	75	23	0	0	2	52	53
Lebanon 2.....	81	14	0	0	2	41	43
Lebanon 3.....	70	29	0	0	4	69	70
Lebanon 4.....	75	24	0	0	3	66	67

TABLE 5.

Relative bird species richness (numbers of species) in consumer classes in fynbos vegetation in the south-western Cape. All figures are percentages, except those for species totals. Figures in parentheses indicate number of study sites in each vegetation type (see Siegfried and Crowe, 1982 for further details, including species lists)

Vegetation type	Insectivores	Granivores	Nectarivores	Others	Total No. species
Strandveld (2)	46-57	29-38	6-8	7-8	35-39
Coastal Renosterveld (1) ...	38	41	9	12	34
Coastal Fynbos (2)	48-51	37-40	4-6	3-11	27-35
Mountain Fynbos (8)	30-55	20-44	12-27	0-10	8-23

entially granivorous species occur regularly in fynbos. *Acacia* and *Burkea* savanna woodland in the Transvaal support similar numbers of granivorous species (Tarboton, 1980). Thus, Winterbottom's (1968a) suggestion that avian species richness is low in fynbos because the flora is poor in seeds suitable for, and available to, birds seems unlikely. Indeed, a relatively fine degree of resource partitioning is shown by differences in diet between six sympatric or partly sympatric *Serinus* (Fringillidae) species in Mountain Fynbos alone (Milewski, 1978).

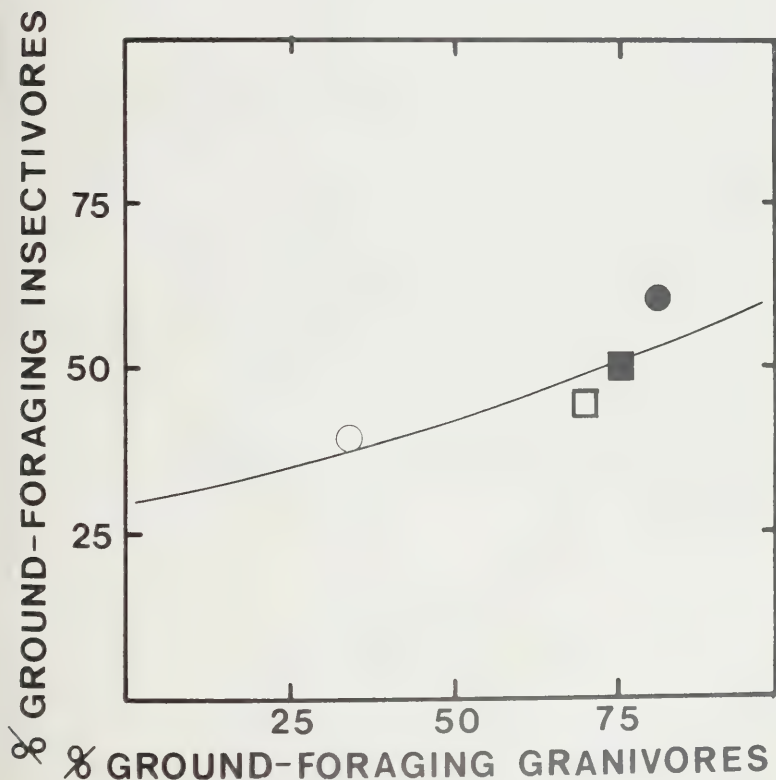


FIG. 6.

Relationship between numbers of insectivorous and granivorous bird species foraging either on ground or in vegetation

○ = Mountain Fynbos,

● = Coastal Fynbos,

□ = Renosterveld,

■ = Strandveld

The insectivores tend to contribute the highest number of species to the fynbos avifauna, closely followed by granivores (Table 5). Together, insectivorous and granivorous birds make up more than 75 % of the total species richness of the fynbos avifauna. A division of insectivorous and granivorous species into ground and above ground (but excluding aerial) foragers shows that the relative incidence of ground foragers in both classes is lowest in Mountain Fynbos and highest in Coastal Fynbos (Fig. 6). The reason for this difference is not clear, but it could be a function of a relatively high seasonal incidence of annual herbaceous plants in the lowland vegetation types.

Seasonality

Perennial plants apparently grow actively during summer in Mountain and Coastal Fynbos, whereas vegetative growth tends to peak during autumn–winter, following onset of the rainy season, in Strandveld and Coastal Renosterveld (Figs 7, 8, 9, 10). Specht (1957) considered a summer peak in growth activity to be an outstanding feature of South Australian heaths, as compared with Mediterranean garrigue and maquis, and Californian chaparral which grow in spring when ambient temperatures are less extreme.

In the relatively fruit-rich Strandveld vegetation both fruiting and flowering activities tend to peak in the austral spring (Fig. 10). A spring flowering peak occurs in comparable vegetation in West and South Australia, California, Chile and Israel (Mooney *et al.*, 1974). Flowering activity in Coastal Fynbos occurs mainly in autumn and winter (Fig. 8). Thus, very broadly speaking, seasonal cycles of vegetative growth and flowering are apparently opposite in Strandveld and Coastal Renosterveld on the one hand, and Coastal Fynbos and also low-altitude Mountain Fynbos on the other hand. The plant phenology of Mountain Fynbos is, however, much more heterogeneous than the relatively uniform patterns applicable to the other vegetation types. In Mountain Fynbos flowering activity apparently varies in relation to both altitude and age of vegetation. Generally in protea-dominated, mature vegetation at low altitudes flowering occurs mainly in winter and spring (e.g. Swartboschkloof, Fig. 7), whereas in erica-dominated, young vegetation at high altitudes flowering tends to be concentrated in summer and autumn (e.g. Sir Lowry's Pass, Fig. 7).

Species specific, age and altitudinal differences in the flowering phenology of Mountain and Coastal Fynbos communities are reflected by marked differences in the seasonal composition of their avifaunas, particularly the nectarivorous class. For instance, Cape sugarbirds *Promerops cafer* are abundant only in winter and spring at Swartboschkloof and in Coastal Fynbos when proteas tend to flower. Orangebreasted sunbirds *Nectarinia violacea* are most abundant in autumn at Sir Lowry's Pass (Figs 11–12) when ericas tend to flower.

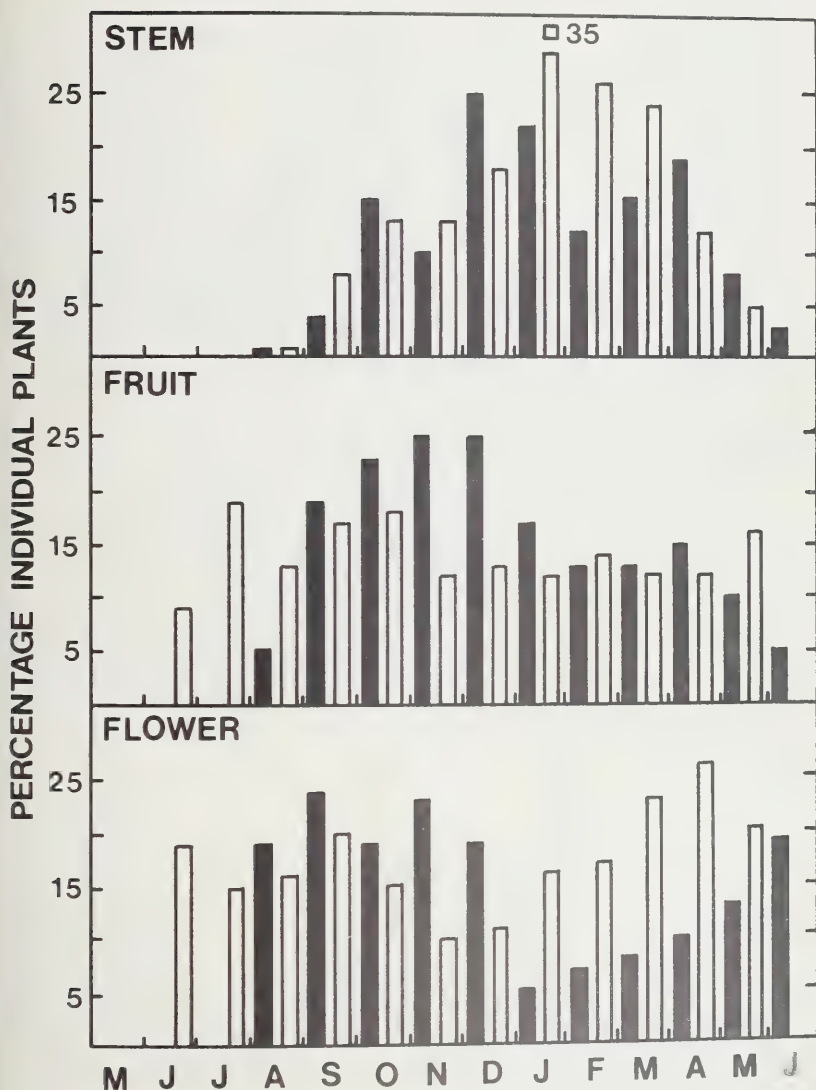


FIG. 7.

Vegetative growth, fruiting and flowering phenology in Mountain Fynbos. Shaded columns are representative of the Swartboschkloof site (404 plants of 50 species sampled August 1978–June 1979) and the unshaded columns represent Sir Lowry's Pass (543 plants of 61 species sampled June 1978–May 1979).

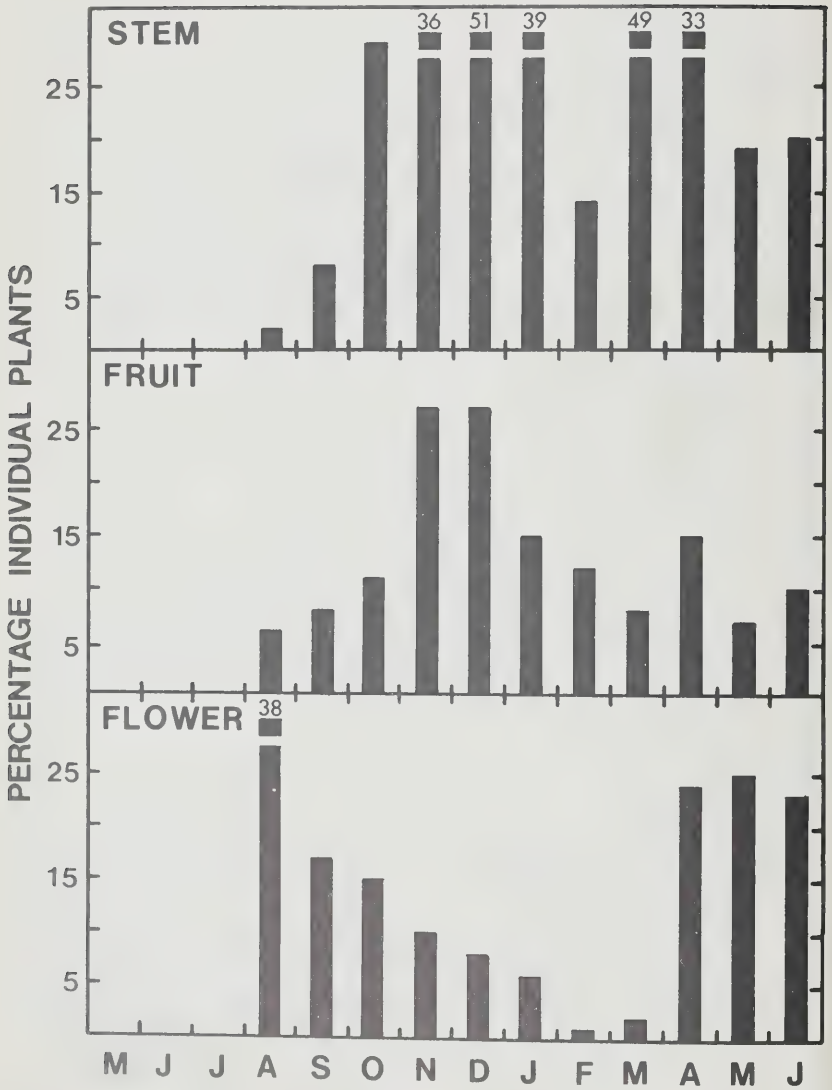


FIG. 8.

Vegetative growth, fruiting and flowering in Coastal Fynbos (Barhuis site; 235 plants of 17 species sampled August 1978–May 1979).

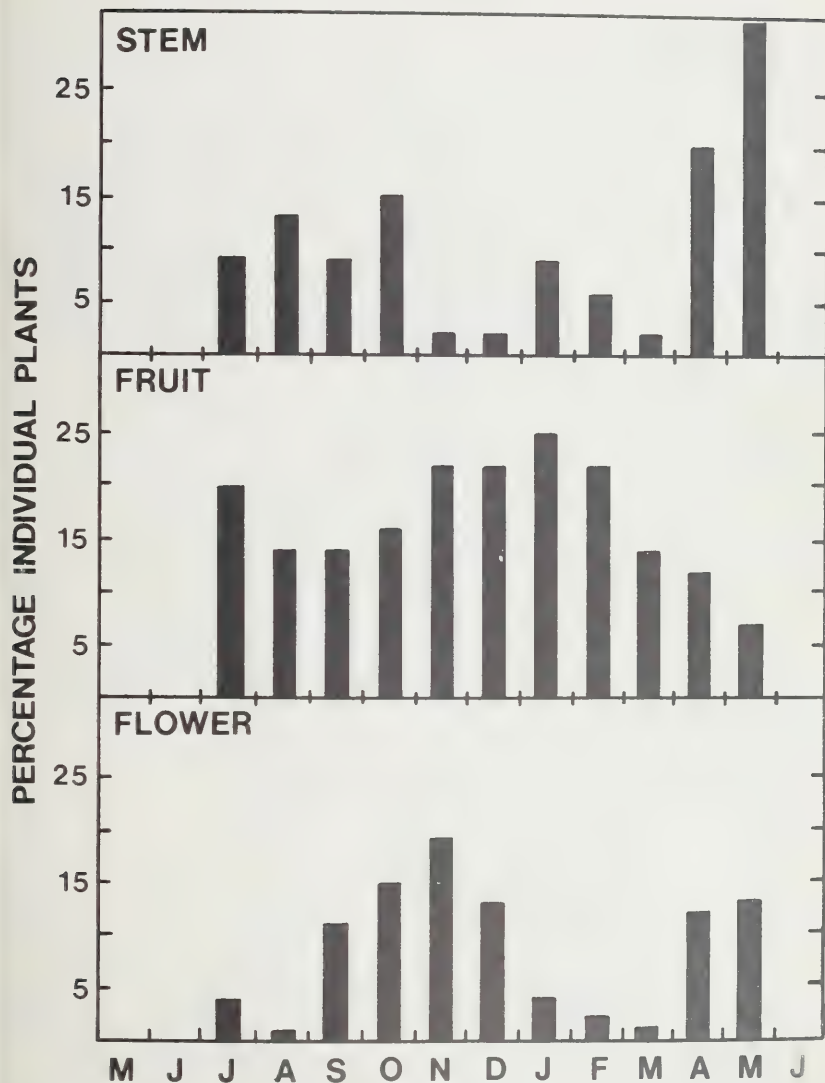


FIG. 9.

Vegetative growth, fruiting and flowering in Renosterveld (De Grendel site; 275 plants of 32 species sampled July 1978–May 1979).

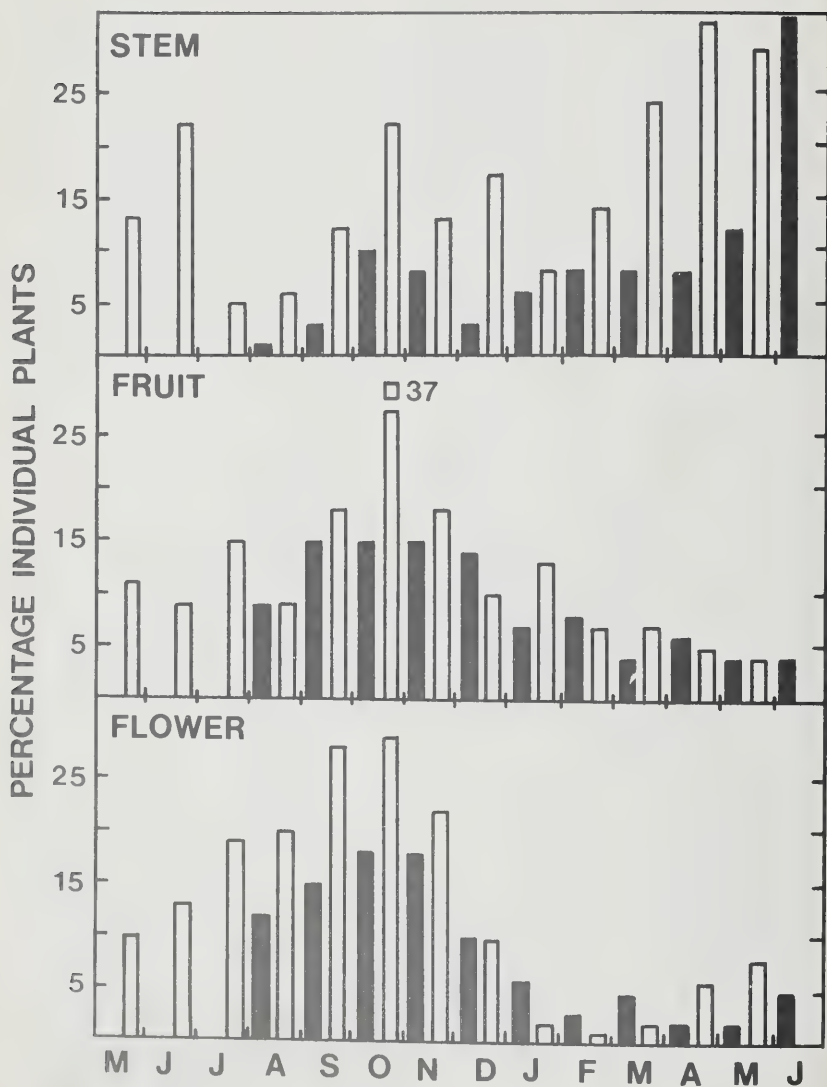


FIG. 10.

Vegetative growth, fruiting and flowering in Strandveld. Shaded columns are representative of the Geelbek site (410 plants of 44 species sampled August 1978–June 1979) and the unshaded columns represent Melkbosch (733 plants of 52 species sampled May 1978–May 1979).

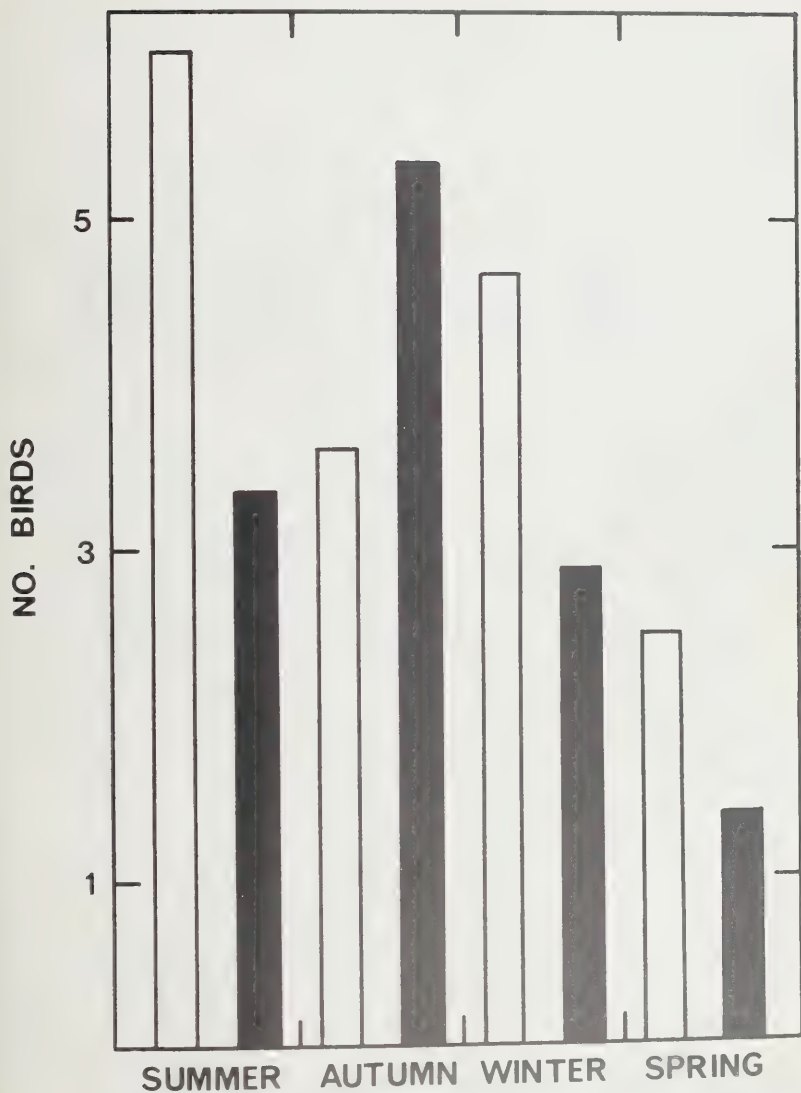


FIG. 11.

Seasonal abundance (mean number of birds in 3 ha) of orangebreasted sunbirds (shaded columns) and all other birds (unshaded columns) in a Mountain Fynbos community (Sir Lowry's Pass). Seasons are: summer (December–February), autumn (March–May), winter (June–August) and spring (September–November).

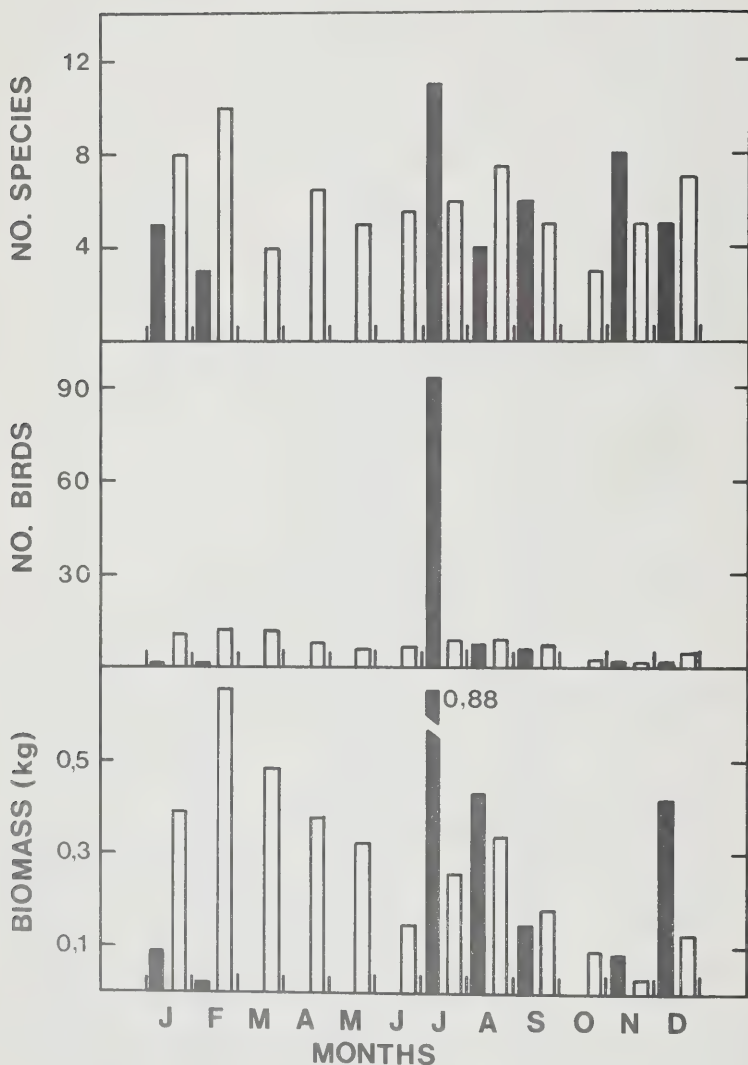


FIG. 12.

Avian species richness (total no. species), mean abundance (no. individuals) and mean biomass (kg live weight) according to months in 3-ha areas in Mountain Fynbos. Shaded columns are representative of the Swartboschkloof site (censuses were not made in March, April, May, June and October) and the unshaded columns represent Sir Lowry's Pass.

Seasonal changes in the species composition and abundance of the bird communities of the other vegetation types apparently are less marked (Figs 13–15). However, in both Coastal Renosterveld and Strandveld small increases in the number of species and larger increases in the abundance of birds tend to occur during the rainy season between April and October (Figs 14–15). These increases coincide with the main growth of annual forbs and grasses as well as the perennial plants. While part of the increase in overall avian abundance is due to recruitment of young birds following breeding which occurs mainly in late winter and early spring (Winterbottom, 1968b), it is primarily granivorous, and to a lesser extent insectivorous, birds which are involved in the population increase preceding the breeding period. Prominent among the granivorous class are the canaries *Serinus canicollis*, *S. alario* and *S. flaviventris* which form wandering, and sometimes large, flocks and commonly include soft green seeds of grasses and composites in their diets (Winterbottom, 1973; Milewski, 1978).

A winter maximum in species richness and abundance of granivorous and insectivorous birds in lowland fynbos formations has been reported also by Winterbottom (1971) who was unable to explain the phenomenon, but suggested that food was unimportant as a controlling factor. His opinion apparently was prompted by a similar suggestion made by Blondel (1969) in explaining why the winter avifauna of the Mediterranean garrigue vegetation is richer than that of summer in both species diversity and biomass. Part of the problem, however, is an artefact caused by a too rigid classification of certain avian populations as belonging to resident or sedentary species. In the fynbos, at least, it seems likely that a number of so-called residents, or sedentary birds, in fact move about extensively, regularly or irregularly, within and between major vegetation formations, in response to fluctuating food resources. It also seems likely that there are regular movements of birds from the Karoo biome into lowland fynbos whose "carrying capacity" is lowest during the dry, hot summer when many plants are either dormant or semi-dormant in Strandveld and Coastal Renosterveld and most annuals are dead in Coastal Fynbos as well.

Leaving aside the swifts (Apodidae) and swallows (Hirundinidae) which seldom are encountered foraging low over fynbos, a striking feature of all fynbos avifaunas is the virtual absence of seasonal visitors in the form of long-distance migrants (Winterbottom, 1971).

Nectarivores and frugivores

Four specialized nectarivorous bird species occur in fynbos, although each species feeds on arthropods as well. In Mountain Fynbos, the Cape sugarbird feeds mainly on nectar and arthropods associated with proteas

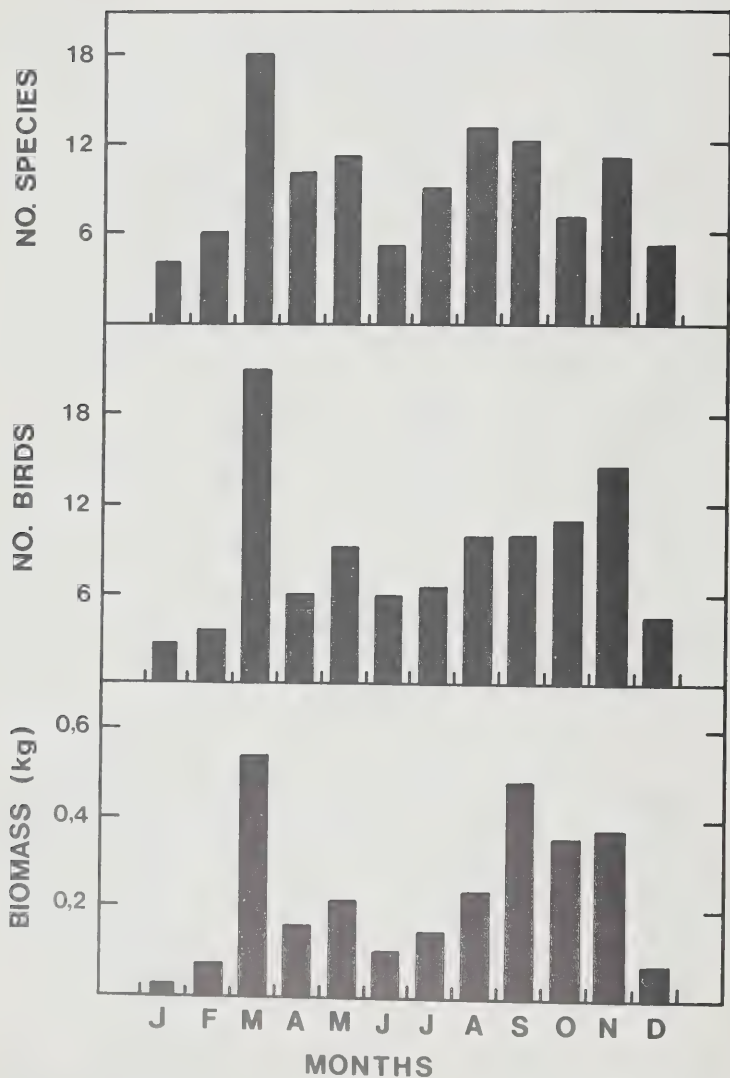


FIG. 13.

Avian species-richness (total no. species), mean abundance (no. individuals) and mean biomass (kg live weight) according to months in a 3-ha area in Coastal Fynbos (Barhuis site).

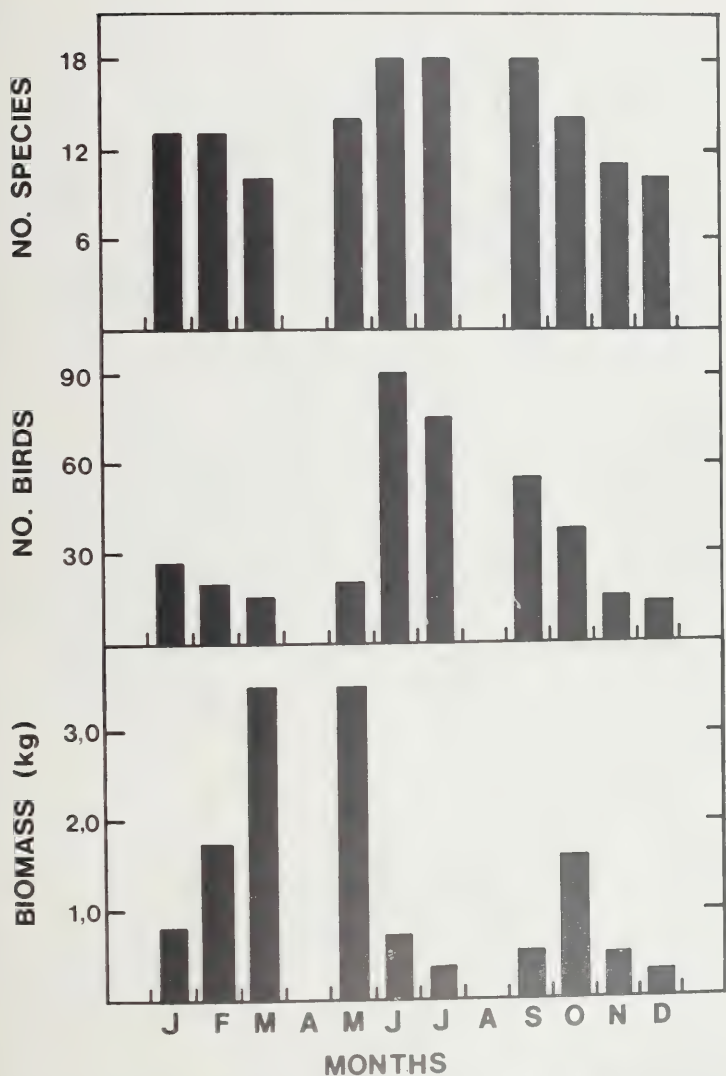


FIG. 14.

Avian species richness (total no. species), mean abundance (no. individuals) and mean biomass (kg live weight) according to months in a 3-ha area in Renosterveld (De Grendel site). Censuses were not made in April and August.

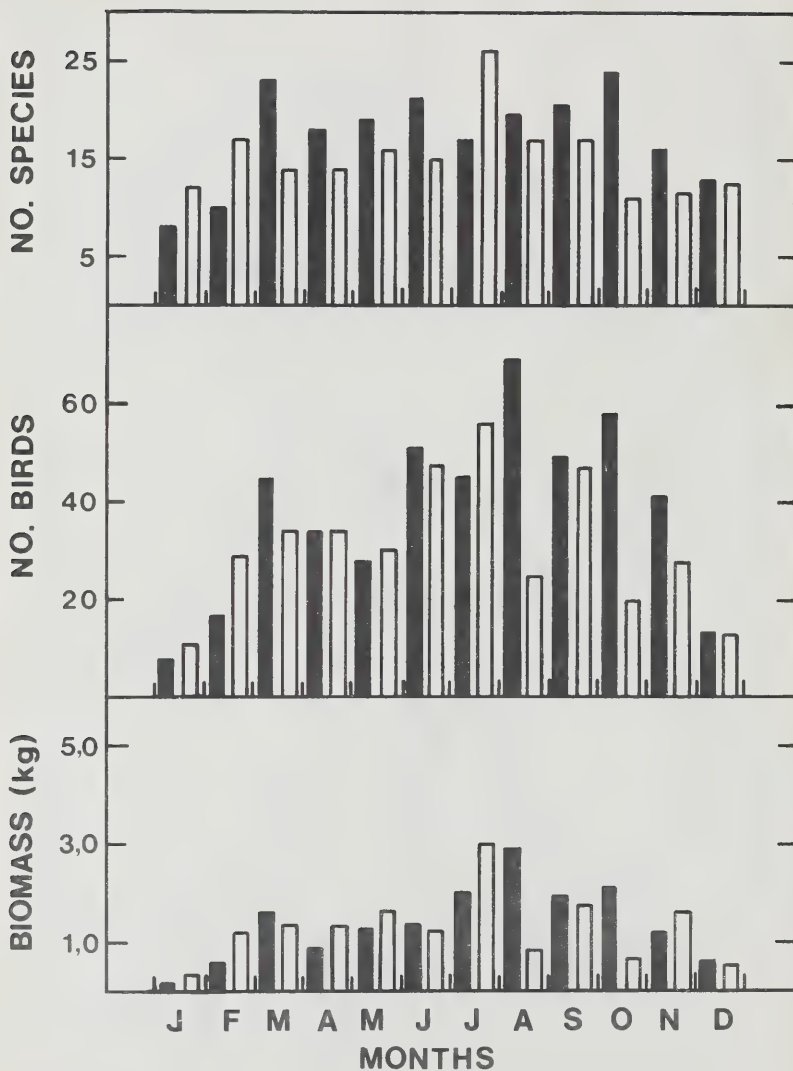


FIG. 15.

Avian species richness (total no. species), mean abundance (no. individuals) and mean biomass (kg live weight) according to months in 3-ha areas in Strandveld. Shaded columns represent the Geelbek site and the unshaded columns represent Melkbosch.

(Mostert *et al.*, 1980), whereas the orangebreasted sunbird tends to take nectar and arthropods associated with ericas (Skead, 1967). Populations of these two species are highly mobile, and they apparently move considerable distances in tracking spatially and temporarily fluctuating food resources (pers. obs.). However, whereas Cape sugarbirds occur regularly in Coastal Fynbos, and occasionally in Strandveld, as well as in Mountain Fynbos, orangebreasted sunbirds seldom are found outside the latter vegetation type (Winterbottom, 1968b; pers. obs.).

The nectar-arthropod resource base provides for an intermediately-sized, third species in the even more itinerant malachite sunbird *Nectarinia famosa* whose populations apparently move widely within and between all four vegetation types of the fynbos. This species may rely to a relatively greater extent on nectar supplies associated with ephemeral sources, such as geophytes (pers. obs.). The fourth specialist nectarivore in the fynbos is the lesser-doublecollared sunbird *Nectarinia chalybea* which approximates the orangebreasted sunbird in size. It is common in the lowland vegetation formation where it, too, has highly mobile populations (Schmidt, 1964). It occurs occasionally in Mountain Fynbos. Thus, Mountain and Coastal Fynbos each essentially has three species, of which two (*P. cafer* and *N. famosa*) are shared, whereas Strandveld and Coastal Renosterveld each essentially has only the same two species (*N. chalybea* and *N. famosa*). This difference probably mirrors the relative abundance of proteas in Coastal and Mountain Fynbos, and the relative abundance of ericas in Mountain Fynbos.

There are no fruit-eating birds permanently resident in Mountain Fynbos. The redwinged starling *Onychognathus morio* occurs itinerantly and sporadically, and it eats fruit but probably takes as much food in the form of insects and other items. Moreover, it is more properly a bird of mountainous areas, rather than Mountain Fynbos, and it undertakes long foraging journeys to forests and other sources of food. The absence of fruit-eating birds in Mountain Fynbos is a consequence of the lack of plants producing fleshy fruits; the possibility that non-avian animals are precluding fruit-eating birds can be discarded. Similarly, the low incidence of fruit-eating birds in Coastal Fynbos reflects a relative paucity of plants with fleshy fruits. This probably means that birds are unimportant as dispersers of plants, and that long-distance dispersal of plants by birds is not favoured in these two vegetation types generally. Many, if not most, of the exceptions are small trees found on the edges of streams or forest and/or are forest pioneers. However, even they produce either small, leathery fruits (e.g. *Heeria argentea*, *Rhus angustifolia*, *R. tomentosa*) or dry capsules (e.g. *Kiggelaria africana*, *Maytenus oleoides*) which dehisce to display seeds, with colourful arils, to birds. A further exception might rest in the fact that Cape sugarbirds transport and incorporate large numbers of protea seeds in their nests (Table 6.

Burger *et al.*, 1976). However, there is, as yet, no evidence for this being a significant form of seed dispersal.

TABLE 6.

Number and mass (g dry wt) of protea seeds (eight spp.) in nests (N = 25) of the Cape sugarbird

No. seeds			Mass seeds			Seeds as % of total mass of nest
\bar{x}	S.D.	Range	\bar{x}	S.D.	Range	
182	189	10-785	2,2	2,5	0,1-9,9	10,6

It is only in the strand and littoral dune communities of all three vegetation types that an enhanced incidence of plants with fleshy fruits is found. However, these seral communities are not fynbos proper but exemplify a complex interplay of fynbos and Afro-montane forest elements in the succession from pioneer littoral to scrub vegetation. Among the dominant plants in these communities, *Euclea racemosa* and *Sideroxylon inerme* produce fleshy fruits and seeds which are dispersed by fruit-eating birds, such as the Cape bulbul *Pycnonotus capensis* and the speckled coly *Colius striatus*. These plants probably have fleshy fruits because directional dispersal of their seeds by birds is the most effective way of colonizing areas which satisfy the species' specific habitat requirements in the form of mesic, sheltered sites.

Broad-leaved fruiting shrubs are common in Strandveld vegetation, normally forming relatively tall clumps interspersed with lower, more open, associations of restios (Restionaceae), succulents, herbs, dwarf shrubs and grasses. Not only are these bush clumps a consequence of localized seed dispersal by birds, but they also help to promote, by providing perches for birds, the spread of the introduced Australian *Acacia cyclops* whose seeds also are dispersed by birds (Glyphis *et al.*, 1981). Prominent among the essentially frugivorous birds of the Strandveld are the Cape bulbul and the colies, especially *Colius indicus*.

CONCLUSIONS

This report was written in response to a request for information on the ecological importance, or otherwise, of birds, which could be useful in developing a strategy for more effective conservation of coastal lowland indigenous vegetation in the south-western Cape. I chose to base the report on a preliminary and provisional trophic classification of the avifaunas and their energy requirements in fynbos communities (at the alpha-diversity level), because, in the absence of detailed information on individual species, this should provide at least some initial insight into the ecological rôles that

the birds play in these ecosystems. Allied to this, I have included botanical information where necessary to reinforce assumptions I make about the importance of nectarivorous and frugivorous birds in ecological processes affecting the functioning of fynbos ecosystems.

In my deliberately broad approach, involving comparisons between the avifaunas of the major fynbos vegetation types, I have forfeited many details which probably would have emerged had I analysed data for variations in trophic structure within community types, as well as between types. In this context, Wiens (1981) has shown that caution and scepticism are in order when viewing the results of broad comparative analyses of avifaunal communities, based on single-year surveys over a variety of sites. According to Wiens (*op cit.*): "Rather consistently, ecological patterns are discerned on broad geographic or temporal scales of resolution, but when one looks to the dynamics of local populations and species assemblages for mechanisms to explain them, the patterns are missing, swamped by local variability." This more likely than not applies especially to bird communities in fynbos ecosystems which generally are characterized by high levels of ecological heterogeneity, on relatively small spatial, and short temporal, scales. I have also not considered a number of potentially important matters, such as the rôle of birds as predators on the seeds of plants and, hence, the way that this might affect the composition of seral communities of fynbos vegetation. Such apparent neglect, in most cases, simply reflects the absence of any worthwhile information, but it also indicates the current lack of a sound conceptual base necessary for beginning an understanding of the factors responsible for the high level of heterogeneity in the organization of fynbos ecosystems.

In spite of these caveats, two major conclusions are contained in this paper which should improve our current understanding of ecological functioning of fynbos ecosystems and, hence, influence current developments for more effective conservation of these ecosystems. First, it seems likely that birds are not major participants in energy or nutrient transfers in fynbos and, thus, energy fluxes and nutrient cycles in these ecosystems are largely the products of ecological interactions between members of other taxa that form part of the structure of the ecosystems. Secondly, birds appear to be important pollinators in fynbos ecosystems. These two conclusions are amplified below.

Because information on primary productivity, and the diets of birds, and on the abundance of their food resources, is either imperfect or lacking all together, it is not yet possible to assess properly the rôles of birds in trophic energy fluxes and mineral element cycles in fynbos ecosystems. However, the estimated annual energy requirements of these bird populations are relatively low. Although this could be taken to mean that much greater amounts

of energy and materials pass through other groups of consumers in fynbos communities, it does not mean that birds exert few, if any, significant effects on the functioning of fynbos ecosystems. Indeed, the observations now available indicate the potential importance of birds, through their patterns of food consumption, either as pollinators, especially in Coastal and Mountain Fynbos, or as seed-dispersers, especially in Strandveld vegetation.

The information available is too meagre to permit a definitive, quantitative assessment of the incidence of bird-pollinated plants in Coastal Fynbos vegetation. However, the data reported in this paper, and casual observations in the field, indicate that at least some Coastal Fynbos communities are rich in plant species which are characterized by the "syndrome of ornithophily". These kinds of plants produce relatively low concentrations of nectar and also have visual or morphological floral features typically facilitating avian pollination (Faegri and Pijl, 1979). Although virtually nothing is known about the interactions between ornithophilous plants and their pollinators in fynbos, it is probably reasonable to assume that a dynamic complex of mutual relationships between birds and plants has evolved in response to co-evolutionary selection. Thus, pollination by birds might affect inter-specific differences in phenology, dispersion and perhaps speciation in Coastal Fynbos plants. This is a subject which merits research.

The integral functioning of untransformed ecosystems encompassing remnant communities of Coastal Fynbos is threatened increasingly by fragmentation and insularization. This already has resulted in the endangerment or extinction of numerous plant species (Hall *et al.*, 1980). As immigration and visitation rates of avian pollinators to these islands of vegetation decrease, as they probably will under conditions of shrinking resources for birds, extinction of plant species must increase and could result in a drastic decline in the Coastal Fynbos flora.

Insularization of Strandveld vegetation is not nearly as far advanced as it is in the case of Coastal Fynbos, and especially Coastal Renosterveld which has been fragmented and reduced to less than 10 % of its former extent by the development of wheatlands (Bigalke, 1979). Moreover, Strandveld generally embraces less dynamic heterogeneity, in the form of successional or other patchiness of avian habitats, than Coastal Fynbos. Thus, while there is a need for a better understanding of the ecological rôles of birds, especially nectarivorous and frugivorous species, in maintaining Strandveld communities, the knowledge is required seemingly less urgently than for Coastal Fynbos and Renosterveld.

A final caveat, however, is based on a current paucity of information concerning a suspected dependence of populations of nectarivorous and, to a lesser extent, frugivorous birds on seasonal occupancy of different vegetation types and, hence, the interdependence of plant communities in these

vegetation types. In short, while it is known that, for instance, populations of the lesser doublecollared sunbird move from one plant community to another within one vegetation type, it is suspected that they might also move between two or more vegetation types. If this is indeed the case, then, a priority prerequisite for an effective conservation strategy for any of the three major types of coastal lowland, indigenous vegetation must be an holistic view of the interdependent functioning of the vegetation types in the south-western Cape.

Clearly, there is a case for urgent research aimed at yielding the knowledge and precepts required for optimization of the dispersion, design and management of nature reserves intended to conserve fynbos communities. Studies of the interrelations of ornithophilous plants and their pollinators should constitute a prominent part of this research for it is crucial to know the spatial and temporal scales of fynbos habitats, including various successional seres and their arrangement, which will ensure the continuing existence of populations of avian pollinators and thereby the populations of plants dependent on these pollinators.

ACKNOWLEDGEMENTS

Thanks are due to R. K. Brooke, R. A. C. Jensen, S. J. Milton, J. C. Sinclair, J. Sommerville and G. D. Underhill for assistance in the field. T. M. and A. Crowe and S. R. Williamson helped with the processing of data. F. J. Kruger and C. Boucher advised in the initial selection of study sites. P. G. H. Frost and A. V. Hall gave helpful advice. The Department of Water Affairs, Forestry and Environmental Conservation, and the Divisional Council of the Cape, allowed access to study sites in areas under their jurisdiction. The South African Council for Scientific and Industrial Research, through its Fynbos Biome Project, and the University of Cape Town provided financial support.

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APPENDIX 1
Plant and bird community study sites and characteristics in the south-western Cape fynbos biome

Site	Co-ordinates	Altitude (m)	Aspect	Slope	Annual ^a rainfall (mm)	Geology	Area (ha)	Vegetation	
								Age (yr)	Type
Melkbosch ...	S 33° 45', E 18° 27'	0-15	W E	0-8°	570	White-grey sandy soil	50	> 15	Strandveld
Geelbek	S 33° 12', E 18° 08'	0-15	W	0-8°	320	Langebaan limestone	50	> 15	Strandveld
De Grendel ..	S 33° 51', E 18° 35'	300	W SW	9-26°	450	Malmesbury slates, Tygerberg formation	50	> 15	Coastal Renosterveld
Barhuis	S 33° 14', E 18° 15'	100	W NW	0-2°	470	White to light red sand	50	—	Coastal Fynbos
Swartboschkloof	S 34° 00', E 18° 57'	300	S SE	9-45°	1 470	Cape granite coarse grained	50	20	Mountain Fynbos
Sir Lowry's Pass	S 34° 09', E 18° 50'	600	N E	0-26°	No data	TMS Peninsula formation	50	5	Mountain Fynbos
Silvermine ...	S 34° 05', E 18° 25'	1 000	NW	0-10°	1 300	TMS Peninsula formation	50	21	Mountain Fynbos
Lebanon 1 ...	S 34° 12', E 19° 08'	700	SW	0-18°	950	TMS Peninsula formation	50	21	Mountain Fynbos
Lebanon 2 ...	—	900	SW	15-25°	—	—	5	5	
Lebanon 3 ...	—	950	SW	30-35°	—	—	40	10	
Lebanon 4 ...	—	1 000	SE	0-35°	—	—	5	10	

^a All 25 year means, except Lebanon (4 yr) and Silvermine (3 yr).

APPENDIX 2

Mass (g live wht) and diet classes for avian species.

1 = raptor, 2 = granivore, 3 = folivore, 4 = insectivore, 5 = scavenger,
6 = frugivore, 7 = nectarivore.

Species	Mass	Diet class
<i>Falco biarmicus</i>	587	1
<i>Falco tinnunculus</i>	130	1
<i>Elanus caeruleus</i>	192	1
<i>Circus maurus</i>	658	1
<i>Francolinus africanus</i>	405	2
<i>Francolinus capensis</i>	750	2
<i>Coturnix coturnix</i>	78	2
<i>Turnix hottentotta</i>	52	2
<i>Columba guinea</i>	350	2
<i>Streptopelia capicola</i>	150	2
<i>Stigmatopelia senegalensis</i>	85	2
<i>Oena capensis</i>	42	2
<i>Colius striatus</i>	52	3
<i>Colius colius</i>	42	3
<i>Colius indicus</i>	58	6
<i>Tricholaema leucomelas</i>	35	4
<i>Geocolaptes olivaceus</i>	170	4
<i>Certhilauda albescens</i>	27	4
<i>Mirafra apiata</i>	29	4
<i>Certhilauda curvirostris</i>	24	4
<i>Eremopterix verticalis</i>	17	4
<i>Corvus albus</i>	700	5
<i>Parus afer</i>	20	4
<i>Anthoscopus minutus</i>	7	4
<i>Chaetops frenatus</i>	41	4
<i>Pycnonotus capensis</i>	40	6
<i>Monticola rupestris</i>	80	4
<i>Monticola explorator</i>	37	4
<i>Cercomela familiaris</i>	21	4
<i>Saxicola torquata</i>	15	4
<i>Cossypha caffra</i>	27	4
<i>Erythropygia coryphaeus</i>	21	4
<i>Bradypterus victorini</i>	10	4
<i>Sphenoeacus afer</i>	31	4
<i>Malcorus pectoralis</i>	11	4
<i>Sylvietta rufescens</i>	11	4
<i>Apalis thoracica</i>	10	4
<i>Cisticola fulvicapilla</i>	9	4
<i>Cisticola subruficapilla</i>	9	4
<i>Prinia maculosa</i>	10	4
<i>Parisoma subcaeruleum</i>	14	4
<i>Parisoma layardi</i>	14	4

Species	Mass	Diet class
<i>Bradornis infuscatus</i>	27	4
<i>Siegelus silens</i>	26	4
<i>Batis capensis</i>	12	4
<i>Lanius collaris</i>	41	4
<i>Laniarius ferrugineus</i>	55	4
<i>Telophorus zeylonus</i>	65	4
<i>Creatophora cinerea</i>	70	4
<i>Spreo bicolor</i>	102	4
<i>Promerops cafer</i>	33	7
<i>Nectarinia famosa</i>	17	7
<i>Nectarinia violacea</i>	10	7
<i>Nectarinia chalybea</i>	9	7
<i>Zosterops pallidus</i>	11	4
<i>Passer melanurus</i>	27	2
<i>Ploceus capensis</i>	45	2
<i>Euplectes orix</i>	24	2
<i>Euplectes capensis</i>	20	2
<i>Serinus totta</i>	30	2
<i>Serinus canicollis</i>	15	2
<i>Serinus alario</i>	12	2
<i>Serinus sulphurata</i>	29	2
<i>Serinus albogularis</i>	26	2
<i>Serinus flaviventris</i>	17	2
<i>Serinus leucoptera</i>	24	2
<i>Fringillaria capensis</i>	21	2

APPENDIX 3

List of plant species, fruit and flower types, at study sites in fynbos vegetation in the south-western Cape.

Fruit type: 1 = fleshy with single seed, 2 = fleshy with numerous seeds, 3 = dry, including pods, nuts, achenes and capsules.

Fruit size: 1 = <3 mm, 2 = 3–10 mm, 3 = >10 mm.

Fruit colour: 1 = white yellow, 2 = orange red, 3 = purple black, 4 = brown green.

Flower size: 1 = <3 mm, 2 = 3–10 mm, 3 = >10 mm.

Flower colour: 1 = brown green, 2 = white yellow, 3 = orange red pink, 4 = blue lilac.

Study sites: 1 = Geelbek, 2 = De Grendel, 3 = Melkbosch, 4 = Swartboschkloof, 5 = Sir Lowry's Pass, 6 = Barhuis, 7 = pre-fire Silvermine, 8 = Lebanon 1, 9 = Lebanon 2, 10 = Lebanon 3, 11 = Lebanon 4, 12 = post-fire Silvermine.

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Adenandra villosa</i>	3	1	4	2	2	5, 12
<i>Agapanthus africanus</i> ...	3	2	3	3	4	4
<i>Agathelpis dubia</i>	3	1	4	1	1	12
<i>Agathosma bifida</i>	3	1	4	1	2	9, 10, 11
<i>A. imbricata</i>	3	1	4	1	2	1
<i>Agyrolobium</i> sp.	3	1	4	2	2	3
<i>Albucca</i> sp.	3	2	4	2	2	1
<i>A. cooperi</i>	3	1	4	2	2	12
<i>Amphibolia indecora</i> ...	3	1	4	2	3	1, 3
<i>Amphithalea</i> sp.	3	1	4	2	3	5
<i>Anagallis arvensis</i>	3	1	4	2	2	1
<i>Anaxeton asperum</i>	3	1	4	1	2	5
<i>Anemone capensis</i>	3	2	4	2	2	10
<i>Anthospermum</i>						
<i>aethiopicum</i>	3	1	4	1	1	1, 2, 3
<i>A. bergianum</i>	3	1	4	1	1	5
<i>A. ciliare</i>	3	1	4	1	1	2
<i>A. prostratum</i>	3	1	4	1	1	8, 9, 10
<i>Antizoma capensis</i>	1	2	2	1	2	1, 2, 3
<i>Arctopus echinatus</i>	3	1	4	2	2	2
<i>Arctotis acaulis</i>	3	1	4	2	3	2
<i>A. breviscarpa</i>	3	2	4	3	3	1
<i>Aristea africana</i>	3	2	4	2	4	12
<i>A. macrocarpa</i>	3	2	4	2	4	12
<i>A. racemosa</i>	3	2	4	2	4	9
<i>A. spiralis</i>	3	1	4	2	4	8, 9, 10, 11
<i>Aspalathus</i> sp.	3	2	4	2	2	7, 12
<i>A. carnosus</i>	3	1	4	2	2	5
<i>A. ciliaris</i>	3	1	4	2	2	2, 5
<i>A. ericaefolius</i>	3	1	4	2	2	2
<i>A. hispida</i>	3	1	4	1	2	3
<i>A. millefolia</i>	3	2	4	2	2	10

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Aspalathus retroflexus</i> . . .	3	2	4	2	2	12
<i>Asparagus capensis</i>	2	2	2	1	2	1, 2, 3, 6
<i>A. compactus</i>	2	2	2	1	2	2
<i>A. crispus</i>	2	2	1	1	2	1, 2, 3
<i>A. stipulaceus</i>	2	2	—	1	2	1, 3
<i>A. thunbergianus</i>	2	2	2	1	2	2, 4
<i>Athrixia crinita</i>	3	1	4	2	2	2
<i>Babiana ambigua</i>	3	1	4	3	4	1, 3
<i>B. plicata</i>	3	1	4	3	4	2
<i>B. tubulosa</i>	3	1	4	3	3	3
<i>Berkheya armata</i>	3	1	4	3	2	2
<i>B. herbacea</i>	3	1	4	2	2	4
<i>B. ilicifolia</i>	3	1	4	3	2	5
<i>Berzelia abrotanoides</i> . . .	3	1	4	1	2	8, 9, 10, 11
<i>Blaeria dumosa</i>	3	1	4	1	3	4, 8, 9, 10, 11
<i>B. ericoides</i>	3	1	4	1	3	5
<i>Bobartia</i> sp.	3	2	4	3	2	3
<i>B. indica</i>	3	2	4	3	2	4, 5
<i>Brunia alopecuroides</i> . . .	3	1	4	1	2	10
<i>B. nodiflora</i>	3	2	4	1	2	4, 9, 10
<i>Bulbine alooides</i>	3	1	4	2	2	2
<i>Bulbinella triquetra</i>	3	1	4	2	2	2
<i>Cannamois acuminata</i> . .	3	1	4	1	1	6
<i>C. virgata</i>	3	2	4	1	1	4
<i>Carpacoe spermacoea</i> . . .	3	2	4	2	1	10
<i>C. vaginellata</i>	3	2	4	2	1	9, 10
<i>Carpobrotus</i> sp.	2	3	4	3	2	5
<i>Cassytha ciliolata</i>	1	2	1	1	2	4
<i>Centella virgata</i>	3	1	4	1	1	5
<i>Cephalophyllum dubium</i> . .	3	1	4	3	2	3
<i>Chironia baccifera</i>	2	2	2	2	3	2
<i>Chondropetalum</i> <i>deustrum</i>	3	2	4	1	1	8, 9, 10, 11
<i>C. hookerianum</i>	3	1	4	1	1	5, 8
<i>Chrysanthemoides</i> <i>incana</i>	1	2	3	2	2	1, 3
<i>C. monilifera</i>	1	2	3	2	2	12
<i>Chrysithrix capensis</i> . . .	3	1	4	1	1	9, 10, 11
<i>C. junciformis</i>	3	1	4	1	1	8
<i>Cineraria geifolia</i>	3	1	4	2	2	3
<i>Cliffortia cuneata</i>	3	1	4	1	1	4
<i>C. graminea</i>	3	1	4	1	1	10, 11
<i>C. ruscifolia</i>	3	1	4	1	1	4
<i>C. subsetacea</i>	3	1	4	1	1	5
<i>Clutia alaternoides</i>	3	1	4	1	2	4, 5

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Clutia daphnoides</i>	3	2	4	1	2	1, 3, 6
<i>C. polygonoides</i>	3	1	4	1	2	2, 9, 10
<i>Coleonema juniperinum</i> ..	3	1	4	1	2	4
<i>Colpoön compressum</i> ..	1	3	3	1	2	1, 3
<i>Commelina</i> sp.	3	1	4	2	2	3
<i>Compositae</i> sp. a	3	1	4	—	—	5
<i>Compositae</i> sp. b	3	1	4	2	—	1
<i>Corymbium africanum</i> ..	3	1	4	2	2	5
<i>C. congestum</i>	3	2	4	1	2	10, 11
<i>C. enerve</i>	3	1	4	2	2	5
<i>C. glabrum</i>	3	1	4	2	3	2, 4, 5, 8, 9, 10
<i>Cotula turbinata</i>	3	1	4	2	2	1
<i>Cotyledon orbiculare</i> ...	3	1	4	3	3	1, 3
<i>C. paniculata</i>	3	1	4	3	3	1, 3
<i>Crassula capensis</i>	3	1	4	2	2	2
<i>C. cymosa</i>	3	1	4	1	2	1
<i>C. fulva</i>	3	1	4	2	2	5
<i>C. muscosa</i>	3	1	4	1	2	1
<i>C. zeyheriana</i>	3	1	4	1	2	1
<i>Cymbopogon marginatus</i>	3	1	4	1	1	4
<i>Cyphia crenata</i>	3	1	4	2	2	3
<i>C. phytiuma</i>	3	1	4	2	2	2
<i>C. volubilis</i>	3	1	4	2	2	1
<i>Diascia unilabiata</i>	3	1	4	2	4	1
<i>Dilatis corymbosa</i>	3	1	4	2	4	5, 7, 12
<i>Diosma hirsuta</i>	3	1	4	1	2	4, 5
<i>D. oppositifolia</i>	3	1	4	1	2	5
<i>Diospyros glabra</i>	1	2	3	1	2	4
<i>Disperis capensis</i>	3	1	4	3	4	5
<i>Drosanthemum</i>						
<i>calycinum</i>	3	1	4	2	—	2
<i>Drosera aliciae</i>	3	1	4	2	3	9, 10, 11
<i>D. hilaris</i>	3	1	4	2	3	8, 9, 10, 11
<i>D. trinerva</i>	3	1	4	2	2	5
<i>Ehrharta calycina</i>	3	1	4	1	1	1, 3, 6
<i>E. dodii</i>	3	1	4	1	1	9
<i>E. erecta</i>	3	1	4	1	1	1
<i>E. ramosa</i>	3	1	4	1	1	1, 9, 10, 11
<i>E. villosa</i>	3	1	4	1	1	6
<i>Elegia</i> sp.	3	1	4	1	1	7
<i>E. asperifolia</i>	3	1	4	1	1	10, 11
<i>E. juncea</i>	3	1	4	1	1	5, 9, 10
<i>E. parviflora</i>	3	1	4	1	1	5
<i>E. racemosa</i>	3	1	4	1	1	4, 5, 8, 9, 10, 11

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Elegia spathacea</i>	3	1	4	1	1	5
<i>E. stipularis</i>	3	2	4	1	1	7
<i>E. vaginulata</i>	3	2	4	1	1	9
<i>Elytropappus</i> sp.	3	1	4	1	1	6
<i>E. rhinocerotis</i>	3	1	4	1	1	2
<i>Epischoenus</i>						
<i>quadrangularis</i>	3	1	4	1	1	8, 10, 11
<i>Eragrostis</i> sp.	3	1	4	1	1	2
<i>Eremia totta</i>	3	1	4	1	2	4
<i>Erepsia pageae</i>	3	1	4	2	3	2
<i>Erica articularis</i>	3	1	4	1	2	4, 5
<i>E. calycina</i>	3	1	4	1	2	11
<i>E. calystegia</i>	—	—	—	—	—	5
<i>E. cerinthoides</i>	3	1	4	3	3	5
<i>E. coccinea</i>	3	1	4	3	3	5, 11
<i>E. corifolia</i>	3	1	4	1	3	5
<i>E. hispidula</i>	3	1	4	1	3	4, 8, 9, 10, 11
<i>E. imbricata</i>	3	1	4	1	2	4, 5
<i>E. longifolia</i>	3	1	4	3	3	5, 9, 10
<i>E. lutea</i>	3	1	4	1	2	5, 11
<i>E. massonii</i>	3	1	4	2	3	5
<i>E. plukenetii</i>	3	1	4	3	3	4, 5, 9, 10
<i>E. pulchella</i>	3	1	4	1	3	5, 7
<i>E. sessiliflora</i>	3	1	4	2	1	8, 9, 10
<i>E. sphaeroidea</i>	3	1	4	—	—	4
<i>E. transparens</i>	3	1	4	1	3	11
<i>Eriocephalus africana</i> ...	3	1	4	1	1	2
<i>E. racemosa</i>	3	1	4	1	4	1, 3
<i>Eriospermum cernuum</i> ..	3	1	4	2	2	12
<i>Eroeda imbricata</i>	3	1	4	2	2	5
<i>Eroedium</i> sp.	3	1	4	1	3	5
<i>Euclea racemosa</i>	1	2	3	1	2	1, 3
<i>Euphorbia burmanii</i>	3	1	4	1	2	1, 3
<i>E. caput-medusae</i>	3	1	4	2	3	1, 3
<i>E. mauritanica</i>	3	1	4	2	2	1, 3
<i>Fagelia bituminosa</i>	3	2	4	2	2	12
<i>Felicia fruticosa</i>	3	1	4	2	4	2
<i>F. tenella</i>	3	1	4	2	4	1
<i>Ficinia bracteata</i>	3	1	4	1	1	4
<i>F. bulbosa</i>	3	1	4	1	1	12
<i>F. capillaris</i>	3	1	4	1	1	4
<i>F. composita</i>	3	1	4	1	1	5
<i>F. deusta</i>	3	1	4	1	1	4, 5, 12
<i>F. dunensis</i>	3	1	4	1	1	1, 3, 6
<i>F. filiformis</i>	3	1	4	1	1	5, 7, 12

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Ficinia lithosperma</i>	3	1	4	1	1	12
<i>F. pinguor</i>	3	1	4	1	1	12
<i>F. tenuifolia</i>	3	1	4	1	1	7
<i>F. zeyheri</i>	3	1	4	1	1	9, 10, 11
<i>Galium tomentosum</i>	3	1	4	1	1	1, 3
<i>Geissorhiza imbricata</i>	3	1	4	2	2	1
<i>Geophyte</i> sp. a	—	—	—	—	—	1
<i>Geophyte</i> sp. b	—	—	—	—	—	1
<i>Geophyte</i> sp. c	—	—	—	—	—	2
<i>Geophyte</i> sp. d	—	—	—	—	—	2
<i>Gerbera asplenifolia</i>	3	1	4	2	2	5
<i>Gnidia humilis</i>	3	1	4	1	2	2
<i>G. pinifolia</i>	3	1	4	2	2	7
<i>Grubbia tomentosa</i>	2	2	3	1	1	8, 9, 10
<i>Haemanthus</i> sp.	1	3	2	3	3	2
<i>Hebenstreitia dentata</i>	3	1	4	1	2	1
<i>H. repens</i>	3	1	4	1	2	1
<i>Helichrysum</i> sp.	3	1	4	—	—	1
<i>H. crassifolium</i>	3	1	4	1	2	2
<i>H. cymosum</i>	3	1	4	1	2	2
<i>H. felinum</i>	3	1	4	2	2	10
<i>H. indicum</i>	3	1	4	—	—	4
<i>H. revolutum</i>	3	1	4	3	2	1, 2, 3
<i>H. sesamoides</i>	3	1	4	2	2	5, 7
<i>H. teretifolium</i>	3	1	4	1	2	1, 2
<i>H. vestitum</i>	3	1	4	3	2	5, 7, 12
<i>Helictotrichon capense</i>	3	1	4	1	1	2
<i>Heliphila scoparia</i>	3	1	4	2	3	5
<i>Helipterum canescens</i>	3	1	4	2	3	5
<i>Hemimeris sabulosa</i>	3	1	4	2	2	1
<i>Herb</i> sp. a	—	—	—	—	—	3
<i>Herb</i> sp. b	—	—	—	—	—	2
<i>Herb</i> sp. c	—	—	—	—	—	2
<i>Hermannia trifoliata</i>	3	1	4	2	3	1, 3
<i>Hermas quinquedentata</i>	3	2	4	1	2	5
<i>H. villosa</i>	3	2	4	1	2	5
<i>Hippia pilosa</i>	3	1	4	2	2	9, 11
<i>Hypodiscus</i> <i>albo-aristatus</i>	3	1	4	1	1	4, 5, 8, 9, 10, 11
<i>H. aristatus</i>	3	1	4	1	1	4, 5, 7, 8, 12
<i>H. willdenowia</i>	3	2	4	1	1	6, 12
<i>Ifloga reflexa</i>	3	1	4	1	2	2
<i>Indigofera heterophylla</i>	3	1	4	1	3	1, 2, 3
<i>I. procumbens</i>		1	4	2	3	1
<i>Klattia partita</i>	3	2	4	2	2	10, 11

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Knowltonia hirsuta</i>	1	2	3	2	2	2
<i>Lachnaea capitata</i>	3	1	4	2	2	6
<i>Lachnospermum</i>						
<i>umbellatum</i>	3	1	4	2	2	9
<i>Lampranthus</i>						
<i>promontorii</i>	3	1	4	2	2	12
<i>Leptocarpus</i> sp.	3	2	4	1	1	11
<i>L. membranaceus</i>	3	1	4	1	2	5, 8, 9, 10
<i>Leucadendron laurum</i>	3	2	4	2	2	7, 12
<i>L. salignum</i>	3	2	3	3	2	5, 6, 7
<i>L. sessile</i>	3	2	3	3	2	5
<i>L. spissifolium</i>	3	2	3	3	2	4, 9, 10, 11
<i>L. xanthoconus</i>	3	2	4	3	1	8, 9, 10
<i>Leucospermum</i>						
<i>conocarpodendron</i>	3	2	1	2	2	5, 11
<i>L. oleaefolium</i>	3	2	1	3	2	5
<i>L. tomentosum</i>	3	2	4	3	2	6
<i>Leyssera gnaphaloides</i>	3	1	4	2	2	1
<i>Lichtensteinia lacera</i>	3	2	4	1	2	4
<i>Limonium roseum</i>	3	1	4	2	3	1, 3
<i>Lobelia</i> sp.	3	1	4	2	4	7
<i>L. comosa</i>	3	1	4	2	4	5
<i>L. coronopifolia</i>	3	1	4	2	4	4, 5, 12
<i>L. pinifolia</i>	3	1	4	2	4	5
<i>Lobostemon hispidus</i>	3	1	4	2	4	2
<i>Lotononis prostrata</i>	3	1	4	2	2	2
<i>Lycium afrum</i>	1	2	3	2	4	2
<i>Maytenus heterophylla</i>	1	1	1	2	2	1
<i>M. maritimus</i>	1	2	1	1	2	1
<i>M. oleoides</i>	1	2	1	1	2	4
<i>Melandrium undulatum</i>	3	1	4	2	2	2
<i>Merxmeullera lanata</i>	3	1	4	1	1	12
<i>M. rufa</i>	3	1	4	1	1	8, 9, 10
<i>M. stricta</i>	3	1	4	1	1	9
<i>Metalasia cephalotes</i>	3	1	4	1	2	4, 5, 12
<i>M. muricata</i>	3	1	4	1	2	4, 5
<i>Metzleria humifusa</i>	3	1	4	1	3	5
<i>Microloma</i> sp.	3	1	4	1	3	1, 3
<i>M. sagittatum</i>	3	1	4	1	3	1, 3
<i>Microstylis villosa</i>	3	1	4	1	2	7, 12
<i>Mimetus cucullatus</i>	3	2	4	3	3	8, 9, 10
<i>Mohria caffrorum</i>	—	—	—	—	—	2
<i>Monochlamys</i> sp.	1	2	1	1	1	1
<i>M. albicans</i>	1	2	1	1	1	2
<i>Montinia caryophyllacea</i>	3	2	4	1	2	4
<i>Muraltia alba</i>	3	1	4	1	2	4

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Muraltia dumosa</i>	3	1	4	1	4	1
<i>Myrica kraussinia</i>	1	2	3	1	1	9, 11
<i>Nebelia fragiraioides</i>	3	1	4	1	2	8
<i>N. paleacea</i>	3	1	4	1	2	5, 9, 10, 11
<i>Nemesia parviflora</i>	3	1	1	2	4	1
<i>Nylandtia spinosa</i>	1	2	2	1	4	3, 6
<i>Olea exasperata</i>	1	2	3	1	2	1, 3
<i>Osmitopsis afra</i>	3	1	4	2	2	9, 10, 11
<i>O. parviflora</i>	3	1	4	2	2	5
<i>Osteospermum</i>						
<i>clandestinum</i>	3	1	4	2	2	2
<i>O. junceum</i>	3	2	4	2	2	9
<i>O. spinosum</i>	3	2	4	2	2	2
<i>Othonna coronopifolia</i> ..	3	1	4	2	2	3
<i>O. cylindrica</i>	3	1	4	2	2	1
<i>O. filicaulis</i>	3	1	4	1	4	1, 3
<i>O. quinquedentata</i>	3	1	4	2	2	5, 9
<i>Oxalis</i> sp. a	3	1	4	2	2	3
<i>Oxalis</i> sp. b	3	1	4	2	—	1
<i>Oxalis</i> sp. c	3	1	4	—	—	4
<i>Oxalis</i> sp. d	3	1	4	2	2	2
<i>Oxalis</i> sp. e	3	1	4	—	—	6
<i>O. eckloniana</i>	3	1	4	2	3	2
<i>O. hirta</i>	3	1	4	2	3	2
<i>O. pes-caprae</i>	3	1	4	2	2	2
<i>Passerina paludosa</i>	3	1	4	1	1	12
<i>P. vulgaris</i>	3	1	4	1	1	3, 6
<i>Pelargonium</i>						
<i>alchemilloides</i>	3	1	4	2	2	2
<i>P. angulosum</i>	3	1	4	2	3	12
<i>P. gibbosum</i>	3	1	4	2	2	1, 3
<i>P. labotum</i>	3	1	4	2	1	2
<i>P. myrrhifolium</i>	3	1	4	2	3	4
<i>P. saniculaefolium</i>	3	1	4	2	3	4
<i>P. triste</i>	3	1	4	2	1	2
<i>Penaea mucronata</i>	3	1	4	1	1	4, 5, 7, 9, 10, 11, 12
<i>Pentaschistis</i> sp. a	3	1	4	1	1	5
<i>Pentaschistis</i> sp. b	3	1	4	1	1	4, 7
<i>P. aristidioides</i>	3	1	4	1	1	12
<i>P. colorata</i>	3	1	4	1	1	4, 8, 9, 10, 11
<i>P. curvifolia</i>	3	1	4	1	1	4
<i>P. palescens</i>	3	1	4	1	1	4, 5
<i>P. tortuosa</i>	3	1	4	1	1	12
<i>Petalacte</i> sp.	3	1	4	1	2	12

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Peucedanum ferulaceum</i>	3	2	4	1	1	9, 10
<i>P. sieberianum</i>	3	2	4	1	2	5
<i>Phaenocoma prolifera</i>	3	1	4	2	3	5
<i>Pharnaceum lanatum</i>	3	1	4	1	1	3, 6
<i>Phillipia leeana</i>	3	1	4	1	1	5
<i>Phyllica cephalantha</i>	3	1	4	1	2	6
<i>P. ericoides</i>	3	1	4	1	2	3
<i>P. gracilis</i>	3	1	4	1	2	4, 8, 9
<i>P. parviflora</i>	3	1	4	1	2	5
<i>P. stipularis</i>	3	1	4	1	2	6
<i>Pinus pinaster</i>	3	2	4	1	1	4
<i>Polyarrhena reflexa</i>	3	1	4	2	2	9
<i>Polycarena cephalophora</i>	3	1	4	2	4	1
<i>Polygala bracteolata</i>	3	1	4	2	4	12
<i>P. myrtiflora</i>	3	1	4	2	4	1
<i>Polygonum undulatum</i>	3	2	4	1	2	2, 5
<i>Priestleya vestita</i>	3	1	4	2	2	5
<i>Printzia aromatica</i>	3	1	4	2	3	2
<i>Prismatocarpus fruticosus</i>	3	1	4	1	2	4
<i>Protea acaulis</i>	3	2	4	3	3	4, 5
<i>P. cynaroides</i>	3	2	4	3	3	5, 8, 9, 10, 11
<i>P. neriifolia</i>	3	2	4	3	3	4, 5, 9
<i>P. nitida</i>	3	2	4	3	2	4
<i>P. repens</i>	3	2	4	3	3	4
<i>P. scabra</i>	3	2	4	3	1	8, 9
<i>P. speciosa</i>	3	2	4	3	3	9, 11
<i>Pseudopentameris</i>						
<i>macrantha</i>	3	1	4	1	1	8, 11
<i>Psoralea aphylla</i>	3	2	4	2	4	9, 10
<i>Pterocelastrus</i>						
<i>tricuspidatus</i>	1	1	2	1	2	1, 3
<i>Putterlickia pyracantha</i>	1	2	2	1	2	1, 2, 3
<i>Rafnia perfoliata</i>	3	1	4	2	2	5
Restiads						8
<i>Restio</i> sp.	3	2	4	1	1	11
<i>R. ambiguus</i>	3	1	4	1	1	8, 10, 11
<i>R. cuspidata</i>	3	1	4	1	1	4, 5, 12
<i>R. dispar</i>	3	1	4	1	1	8, 9, 10, 11
<i>R. egregius</i>	3	1	4	1	1	5, 8, 10
<i>R. eleocharis</i>	3	1	4	1	1	3
<i>R. filiformis</i>	3	1	4	1	1	4, 5
<i>R. gaudichaudianus</i>	3	1	4	1	1	4
<i>R. monanthus</i>	3	1	4	1	1	6
<i>R. perplexus</i>	3	1	4	1	1	8, 10
<i>R. purpurascens</i>	3	1	4	1	1	10

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Restio tenuissimus</i>	3	1	4	1	1	5, 7, 12
<i>R. triteceus</i>	3	1	4	1	1	4, 5, 7, 8, 9, 10
<i>Rhus angustifolia</i>	1	2	1	1	2	2, 4
<i>R. glauca</i>	1	2	2	1	2	1, 3
<i>R. incana</i>	1	2	2	1	2	2, 3
<i>R. mucronata</i>	1	2	2	1	2	1, 3
<i>R. rosmarinifolia</i>	1	2	1	1	2	4
<i>Roella ciliaris</i>	3	1	4	2	4	5, 12
<i>Ruschia carolii</i>	3	1	4	2	4	3
<i>Salsola australis</i>	3	1	4	1	1	1
<i>Salteria sarcocolla</i>	3	1	4	2	3	5
<i>Salvia africana</i>	3	1	4	2	4	2
<i>S. aurea</i>	3	1	4	3	3	1, 2, 3
<i>Schizaea pectinata</i>	—	—	—	—	—	8, 9, 10, 11, 12
<i>Scyphogyne muscosa</i>	3	1	4	1	3	5, 12
<i>Selago spuria</i>	3	1	4	1	4	4, 12
<i>Senecio</i> sp.	3	1	4	—	—	5
<i>S. aloides</i>	3	1	4	—	—	1
<i>S. elegans</i>	3	1	4	2	4	1
<i>S. grandiflorus</i>	3	2	4	2	2	12
<i>S. lineatus</i>	3	1	4	2	2	2
<i>S. pinifolius</i>	3	1	4	2	2	2, 9
<i>S. purpureus</i>	3	1	4	2	4	5
<i>S. rigidus</i>	3	1	4	2	2	7, 9, 12
<i>S. umbellatus</i>	3	1	4	2	4	5, 9, 10, 11
<i>Serruria elongata</i>	3	1	4	2	3	5
<i>Sickmannia radiata</i>	3	2	4	2	2	12
<i>Solanum</i> sp.	2	2	—	2	—	3
<i>S. guineense</i>	2	2	3	2	4	1, 2, 3
<i>Spiloxene capensis</i>	3	1	4	2	2	2
<i>Staberoha cernua</i>	3	1	4	1	1	4, 5, 7, 8, 9, 10, 12
<i>S. distachya</i>	3	1	4	1	1	6
<i>Stachys aethiopicum</i>	3	1	4	2	2	1, 2
<i>Stilbe vestitum</i>	3	1	4	1	2	12
<i>Stoebe</i> sp.	3	1	4	1	1	12
<i>S. aethiopica</i>	3	1	4	1	2	5
<i>S. cinerea</i>	3	1	4	1	1	4, 9, 10
<i>S. incana</i>	3	1	4	1	1	7, 9, 10, 11
<i>S. spiralis</i>	3	1	4	1	2	5
<i>Struthiola hirsuta</i>	3	1	4	2	2	5
<i>S. linearis</i>	3	1	4	2	2	5
<i>S. myrsinites</i>	3	1	4	2	2	8
<i>Sutera hispida</i>	3	1	4	2	2	2

Species	Fruit			Flower		Study sites
	Type	Size	Colour	Size	Colour	
<i>Sympieza articulata</i>	3	1	4	1	2	8
<i>Synnotia villosa</i>	3	1	4	3	2	2
<i>Teloschistes capensis</i>	—	—	—	—	—	1
<i>Tetragonia fruticosa</i>	3	1	4	1	2	1, 2, 3
<i>T. spicata</i>	3	2	4	1	2	2
<i>Tetraria autumnalis</i>	3	1	4	1	1	4
<i>T. brevicaulis</i>	3	1	4	1	1	5, 8, 10, 11
<i>T. bromoides</i>	3	1	4	1	1	5, 8, 9, 10
<i>T. compacta</i>	3	1	4	1	1	5, 7
<i>T. compar</i>	3	1	4	1	1	12
<i>T. cuspidata</i>	3	1	4	1	1	4, 5
<i>T. exilis</i>	3	1	4	1	1	8, 9, 10, 11
<i>T. fasciata</i>	3	1	4	1	1	4, 9, 10
<i>T. fimbriolata</i>	3	1	4	1	1	8, 9, 10
<i>T. flexuosa</i>	3	1	4	1	1	5, 7, 8, 9, 10, 11, 12
<i>T. thermalis</i>	3	1	4	1	1	4, 5, 8, 11
<i>T. triangularis</i>	3	2	4	1	1	11
<i>T. ustulata</i>	3	1	4	1	1	4, 7
<i>Thamnochortus</i> <i>dichotomus</i>	3	1	4	1	1	4, 5
<i>T. fruticosus</i>	3	2	4	1	1	7, 12
<i>T. gracilis</i>	3	1	4	1	1	5, 8, 9, 10, 11
<i>T. obtusus</i>	3	1	4	1	1	6
<i>T. similis</i>	3	2	4	1	1	9
<i>T. spicigerus</i>	3	1	4	1	1	1, 3
<i>Themeda triandra</i>	3	1	4	1	1	4
<i>Thesium</i> sp.	3	1	4	1	1	11

A LIST OF THE *LACHENALIA* SPECIES INCLUDED IN RUDOLF SCHLECHTER'S COLLECTIONS MADE IN 1891-1898 ON HIS COLLECTING TRIPS IN SOUTHERN AFRICA, WITH IDENTIFICATIONS ADDED

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ABSTRACT

A numerical list of Rudolf Schlechter's *Lachenalia* collections made during 1891-1898 on his collecting trips in Southern Africa, with identifications added, has been compiled from his duplicate specimens examined in 15 herbaria, to assist in bringing all his numerous sets of duplicate specimens in these and other herbaria up to date.

UITTREKSEL

'N LYS VAN DIE *LACHENALIA* EKSEMPLE IN RUDOLF SCHLECHTER SE VERSAMELINGS WAT IN 1891-1898 IN SUIDER-AFRIKA GEMAAK IS, MET IDENTIFIKASIES BYGEVOEG

Die *Lachenalia* eksemplare deur Rudolf Schlechter versamel gedurende sy versameltoegte in Suider-Afrika vanaf 1891-1898, is chronologies genommer en identifika-sies is bygevoeg. Die lys is saamgestel deur sy duplikaat-eksemplare in 15 herbaria te ondersoek, sodat sy groot aantal duplikaat-stelle in hierdie, en ander herbaria op datum kan word.

INTRODUCTION

Various sets of Rudolf Schlechter's specimens obtained on his collecting trips in Southern Africa during 1891-1898 were distributed to many herbaria, particularly those in South Africa, Europe and Scandinavia. Among these collections were a large number of *Lachenalia* specimens, about half of which were either not identified at specific level, or were given specific names, some of which were incorrect. To the rest Schlechter had added his own manuscript names. A number of the latter have been described or have had their manuscript names validated in recent publications, others have been correctly identified, while a few have not yet been described or are difficult to identify with certainty at present.

It has therefore been decided to publish an interim list of these speci-

Accepted for publication 5th July, 1982.

mens, correctly identified where possible, in order to assist in bringing these widely distributed collections up to date.

In compiling this list the "Itinerary of Rudolf Schlechter's Collecting Trips in Southern Africa" by J. P. Jessop, published in the *Journal of South African Botany* 30(3), July, 1964, was used as a basis, and the relevant dates, localities, and register numbers from it have been adopted as headings to each item.

In addition, Rudolf Schlechter's specimens from the following 15 herbaria were examined and identified: B, BM, BOL, C, G, GRA, K, L, LD, PRE, S, SAM, UPS, WU, Z.

In the list details from Schlechter's field tickets have been given opposite each of his register numbers, which are arranged in numerical order, in the left hand column, and the correct or tentative identifications have been added below, followed by the symbols of the herbaria in which the specimens were studied.

A number of inconsistencies were observed in the labelling, as at times dates vary slightly on labels with the same register numbers, at others the figures appear to have been transposed on labels with the same dates and other particulars.

In several instances mixed gatherings were found, when two species were represented on the same sheet, or two different species on separate sheets had been given the same number. In these cases it is advisable to check the specimens with the descriptions of the species.

I wish to express my thanks and appreciation to all Directors and Curators of the herbaria mentioned, who made their collections and facilities available during visits to their institutions, or sent specimens out on loan. Special thanks are due to Professor E. A. Schelpe of the Bolus Herbarium, University of Cape Town and to Dr. J. P. Rourke of the Compton Herbarium, Kirstenbosch, for their assistance and advice during my researches on the genus *Lachenalia*.

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RUDOLF SCHLECHTER'S *LACHENALIA* SPECIES

13/6/1892 ? Rondebosch Common (Camp Ground)

830 *Lachenalia*

In arenosis humidis Camp Ground prope Cape Town

12.VI.92 *R. Schlechter* 830

Lachenalia juncifolia Bak. (Z).

- 830 **Lachenalia juncifolia** Bak. on same sheet
Lachenalia unifolia Bak. var. (G, Herb. Bois).

- 15-16/7/92 Sir Lowry's Pass
 1189 *Lachenalia*
 In clivis arenosis pr. Sir Lowry's Pass
 15.VII.1892 *R.Schlechter* 1189
Lachenalia unifolia Jacq. var. **wrightii** Bak. (Z).

- 29/7/92 Claremont
 1238 *Lachenalia reflexa* Thunb.
 Cape Flats pr. Claremont
 29.VII.1892 *R.Schlechter* 1238
Lachenalia reflexa Thunb. (GRA, Z).

- 29/7/92 Claremont
 1283 *Lachenalia reflexa* Thunb.
 Cape Flats pr. Claremont
 29.VII.1892 *R.Schlechter* 1283
Lachenalia reflexa Thunb. (G, S, WU).

- 31/7/92 Retreat and Muizenberg
 1251 *Lachenalia rubida* Jacq.
 In arenos litoralis Muizenberg
 31.VII.1892 *R.Schlechter* 1251
Lachenalia bulbifera (Cyrillo) Hort. ex Asch. & Graeb. (G,
 GRA, S, WU, Z).

- 27/8/92 Lion's Mountain
 1343 *Lachenalia orchiioides* Ait.
 In clivis Leonus Cape Town
 27.VIII.1892 *R.Schlechter* 1343
Lachenalia fistulosa Bak. (GRA, PRE, Z).

- 4/9/92 New Kloof, Tulbagh and Tulbagh Waterfall
 1431 *Lachenalia*
 In planitiae pr. Tulbagh
 4.IX.1892 *R.Schlechter* 1431
Lachenalia unifolia Jacq. (Z).

- 17/8/94 Saron (4847–4849 and 4861–4878)
4849 *Lachenalia orchiioides* Jacq.
In arenosis prope Saron
17.VIII.1894 R.Schlechter 4849
Lachenalia pallida Ait. (BM, G, SAM, Z).
- 17/8/94 Piquetberg Road. Piquetberg Road is now Gouda (4850–4856)
4855 *Lachenalia schlechteri* Bak.
In planitae pr. Piquetberg Road 600'
17.VIII.1894 R.Schlechter 4855
Lachenalia schlechteri Bak. (in Baker's hand)
Holotype (Z).
- 24–25/8/94 Olifants River (4989–5031)
5018 *Lachenalia* cf. *glaucina* Jacq.
In rip. flum. Olifants River 133 m.
25.VIII.1894 R.Schlechter 5018
Lachenalia trichophylla Bak. (BM, C, G, GRA, K, S, UPS, Z).
- 24–25/8/94 Olifants River (4989–5031)
5024 *Lachenalia trichophylla*
Olifants River 400'
25.VIII.1894 R.Schlechter 5024
Lachenalia trichophylla Bak. (GRA).
- 24–25/8/94 Olifants River (4989–5031)
5025 *Lachenalia hirta* Thunb.
In rip. flum. Olifants River
25.VIII. 1894 R.Schlechter 5025
Lachenalia hirta Thunb. (C, G, GRA, PRE, S, UPS).
- 5–10/9/94 Piquetberg (5180–5277)
5239 *Lachenalia tricolor* Thunb.
In planitae summi montis Piquetberg 1 800'
9.IX.1894 R.Schlechter 5239
Lachenalia aloides (L.f.) Hort. ex Asch. & Graeb. var. (Z).
- 5–10/9/94 Piquetberg (5180–5277)
5274 *Lachenalia unicolor* Jacq.
In collib. ad flumen Berg River nr Piquetberg
10.IX.1894 R.Schlechter 5274
Lachenalia unicolor Jacq. var. (GRA, Z).

List of Lachenalia species in Schlechter's collections with identifications 49

- 11/9/94 Braakfontein. Locality has not been identified
 5315 *Lachenalia*
 In collibus pr. Braakfontein 45 m.
 11.IX.1894 *R.Schlechter* 5315
Lachenalia bachmannii Bak. (PRE, Z).
- 14-15/10/94 Houw Hoek and Bot River (5434-5523)
 5507 *Lachenalia*
 In arenosis Houw Hoek
 15.X.1894 *R.Schlechter* 5507
Lachenalia rosea Andr. (Z).
- 28-30/6/96 Piqueniers Kloof (7928-7961)
 7937 *Lachenalia ophioglossoides* Schltr. n. sp. MS.
 Piqueniers Kloof
 28.VI.1896 *R.Schlechter* 7937
Lachenalia sp. indet. cf. *L. mutabilis* Sweet and *L. variegata*
 Barker (BM, GRA, K, Z).
- 5-6/7/96 Langekloof and Bulshoek. The Lang Kloof runs NW of Clan-
 william (8029-8050)
 8053 *Lachenalia satyrioides* Schltr. n. sp. MS.
 Lange Kloof in aridis 500'
 6.VII.1896 *R.Schlechter* 8053
Lachenalia undulata Masson (BM, G, GRA, K, L, PRE, S,
 Z).
- 17-21/7/96 Kareebergen. The farm Kareebergen is about 13 miles SE of
 Bitterfontein (8167-8258)
 8243 *Lachenalia versicolor* Jacq.
 Karee Bergen 2 000'
 21.VII.1896 *R.Schlechter* 8243
Lachenalia splendida Diels (BM, BOL, G, GRA, K, L, PRE,
 S, Z).
- 21/7/96 Klein Vlei (8259-8261)
 8260 *Lachenalia pachycaulos* Schltr. n. sp. MS.
 Klyn Fontein in saxosis 1 500'
 21.VII.1896 *R.Schlechter* 8260
Lachenalia mutabilis Sweet var. (BM, G, GRA, K, PRE).
- 8260 A mixture of *L. mutabilis* Sweet var. and *L. framesii* Barker
 (Z).

- 23/7/96 Zout Rivier (8314-8318)
 8315 *Lachenalia Loeseneriana* Schltr. n. sp. MS.
 Zout Rivier in arenosis 1 000'
 28.VII.1896 *R.Schlechter* 8315
Lachenalia mutabilis Sweet var. (B, BM, BOL, GRA, K, PRE, S).
 8315 ***Lachenalia framesii*** Barker (G, L, PRE, Z).
- 3/8/96 Langekloof (8385-8401)
 8398 *Lachenalia ventricosa* Schltr. n. sp. MS.
 Langekloof in sabulosis
 3.VIII.1896 *R.Schlechter* 8398
Lachenalia ventricosa Schltr. ex Barker (B, BM, BOL, G, GRA, K, PRE, Z).
- 12-13/8/96 Zeekoe Vlei. Zeekoe Vlei is about 9 miles W. of Clanwilliam
 (8480-8510)
 8490 *Lachenalia neglecta* Schltr. n. sp. MS.
 Zeekoe Vley in sabulosis 600'
 12.VIII.1896 *R.Schlechter* 8490
Lachenalia neglecta Schlecht. n. sp. MS. (B, BM, BOL, G, GRA, K, L, PRE, S, Z).
 A new species? Not yet published.
- 25/8/96 Boontjies Rivier. The Boontjies River joins the Brandewyn
 Rivier about 4 miles ENE of Pakhuis (8663-8678)
 8670 *Lachenalia unicolor* Jacq.
 Boontjies River
 25.VIII.1896 *R.Schlechter* 8670
Lachenalia unicolor Jacq. var. (BM, G, GRA, K, L, PRE, Z).
- 25/8/96 Boontjies Rivier (8663-8678)
 8678 *Lachenalia trichophylla* Bak.
 Boontjies Rivier
 25.VIII.1896 *R.Schlechter* 8678
Lachenalia trichophylla Bak. (BM, G, GRA, K, L, PRE, S, Z).
- 26/8/96 Bidouwberg. The Bidouwberg is N of the Bidouw River
 (8681-8695)

- 8687 *Lachenalia monophylla* Jacq. (probably meant for *L. unifolia* Jacq.)
 Bidouw Berg 3 600'
 26.VIII.1896 *R.Schlechter* 8687
Lachenalia bolusii Barker (BM, K).
- 26/8/96 Bidouwberg (8681–8695)
 8689 *Lachenalia monophylla* Jacq. (probably meant for *L. unifolia* Jacq.)
 Bidouw Berg 3 600'
 26.VIII.1896 *R.Schlechter* 8689
Lachenalia bolusii Barker (BOL, G, GRA, K, L, PRE, Z).
- 28–31/8/96 Koudeberg near Wupperthal (8718–8787)
 8725 *Lachenalia maximiliani* Schltr. n. sp. MS.
 Koude Berg in saxosis
 28.VIII.1896 *R.Schlechter* 8725
Lachenalia maximiliani Schltr. ex Barker (BOL, BM, G, GRA, K, L, PRE, S, Z).
- 28–31/8/96 Koudeberg near Wupperthal (8718–8787)
 8771 *Lachenalia Schwolkeana* Schltr. n. sp. MS.
 Koude Berg
 30.VIII.1896 *R.Schlechter* 8771
Lachenalia elegans Barker var. (B, BM, G, GRA, K, L, PRE, S, Z).
- 10–11/9/96 Michells Pass (8931–8970)
 8968 *Lachenalia pulchella* Schltr. n. sp. MS.
 Michells Pass
 11.IX.1896 *R.Schlechter* 8968
Lachenalia unicolor Jacq.
 var. **fragrans** (Jacq.) Bak. (B, BM, G, GRA, K, L, PRE, S, Z).
- 24–26/11/96 Houw Hoek (9374–9435)
 9403 *Lachenalia montana* Schltr. n. sp. MS.
 Houw Hoek
 24.XI.1896 *R.Schlechter* 9403
Lachenalia montana Schltr. ex Barker (BM, BOL, G, GRA, K, L, PRE, S, Z).

- 28/11/96 Dunes near Hawston (9459–9480)
 9473 *Lachenalia*
 Dunes near Hawston
 28.XI.1896 *R.Schlechter* 9473
Lachenalia rosea Andr. (BM, G, GRA, K, L, PRE, S, Z).
- 30/11/96- Vogelgat. Vogelgat is to the NE of the Mouth of the Klein
 2/12/96 River (9507–9579)
 9530 *Lachenalia*
 1.XII.1896 *R.Schlechter* 9530
Lachenalia salteri Barker (BM, BOL, G, GRA, K, L, PRE, S, Z).
- 10/4/97 Onrust River (10395–10399)
 10395 *Lachenalia rubida* Jacq.
 Onrust River
 10.IV.1897 *R.Schlechter* 10395
Lachenalia rubida Jacq. (BM, G, GRA, K, L, PRE, S, Z).
- 21/4/97 Elim (10471–10476)
 10471 [*Lachenalia Kunickiana* Schltr. n. sp.] MS.
 Elim
 21.IV.1897 *R.Schlechter* 10471
Polyxena sp. (B, BM, G, L, S, Z).
- 26/4/97 Zeekoevlei. Zeekoevlei is about 6 miles S of Bredasdorp
 (10549–10551)
 10549 *Lachenalia pusilla* Jacq.
 Zeekoevley
 26.IV.1897 *R.Schlechter* 10549
Lachenalia pusilla Jacq. (BM, G, K, L, SAM, S, Z).
- Oct. 1896 Saron
 10646 *Lachenalia contaminata* Bak.
 In collibus prope Saron
 Oct. 1896 *R.Schlechter* 10646
Lachenalia contaminata Ait. (BM, G, GRA, K, L, PRE, Z).
 This number presents some problems, as it comes much later in the sequence than the date would indicate. It may possibly have been added to the ticket at this later date as its flowering time is during September–October and not in July as its numerical position would indicate.

- 4-5/8/97 Porterville (10714-10745)
 10716 *Lachenalia glaucina* Jacq.
 In collibus pone Porterville
 4.VIII.1897 *R.Schlechter 10716*
Lachenalia longibracteata Phillips (BM, G, K, L, PRE, S, Z).
- 4-5/8/97 Porterville (10714-10745)
 10740 *Lachenalia sessiliflora* Schltr. n. sp. MS.
 In collibus pone Porterville
 5.VIII.1897 *R.Schlechter 10740*
Lachenalia sp. indet. cf. *L. mutabilis* Sweet & *L. variegata*
 Barker (BM, G, GRA, K, PRE, S, Z).
- 10-12/8/97 Packhuisberg (10793-10819)
 10816 *Lachenalia montigena* Schltr. n. sp. MS.
 Pakhuisberg
 12.VIII.1897 *R.Schlechter 10816*
Lachenalia elegans Barker var. (BM, G, GRA, K, L, PRE, S, Z).
- 13/8/97 Brandewyn Rivier (10820-10830)
 10827 *Lachenalia ventricosa* Schltr. n. sp. MS.
 Brandewyn Rivier
 13.VIII.1897 *R.Schlechter 10827*
Lachenalia ventricosa Schltr. ex Barker (BM, BOL, G, GRA, K, L, LD, PRE, S, Z).
- 14/8/97 Lammkraal. No Lammkraal has been found but there is a
 Langkraal about seven miles past the Brandewyn Rivier
 (10832-10850)
 10842 *Lachenalia violacea* Jacq.
 Lammkraal in collibus
 14.VIII.1897 *R.Schlechter 10842*
Lachenalia violacea Jacq. (PRE).
- 15/8/97 Agtertuin. Agtertuin is about 4 miles from the Doorn River
 on the Clanwilliam side (10851-10868)
 10856 *Lachenalia physopus* Schltr. n. sp. MS.
 Agtertuin in collibus
 15.VIII.1897 *R.Schlechter 10856*
Lachenalia violacea Jacq. (B, BM, G, GRA, K, L, LD, S, Z).

- 16/8/97 Doornrivier (10869–10884)
 10878 *Lachenalia picta* Schltr. n. sp. MS.
 Doornfontein in collibus
 16.VIII.1897 *R.Schlechter 10878*
Lachenalia schlechteri Bak. (B, BM, G, GRA, K, L, PRE, S, Z).
- 18–19/8/97 Papelfontein. This is probably Papkuilsfontein, about 26 miles
 E of Van Rhynsdorp (10890–10913)
 10907 *Lachenalia obscura* Schltr. n. sp. MS.
 Papelfontein
 19.VIII.1897 *R.Schlechter 10907*
Lachenalia obscura Schltr. n. sp. MS. (B, BM, G, GRA, K, L, PRE, S, Z).
 A new species? Not yet published.
- 7–9/9/97 Brackdam. Brackdam is about 10 miles N of Garies
 (11160–11161)
 11160 *Lachenalia sessiliflora* Schltr. n. sp. MS.
 Brackdam in collibus 2 000'
 9.IX.1897 *R.Schlechter 11160*
Lachenalia carnososa Bak. (BM, PRE).
 11160 **Lachenalia framesii** Barker (G, K, L, LD, S, Z).
- 12–13/9/97 I'Aus. Ouss is an old name for Kamieskroon
 (11203–11234)
 11203 *Lachenalia uniflora* Jacq. (probably *L. unifolia* Jacq. is meant)
 I'Aus in collibus 2 300'
 12.IX.1897 *R.Schlechter 11203*
Lachenalia schlechteri Bak. (BM, G, GRA, K, L, PRE, S).
- 12–13/9/97 I'Aus. Ouss is an old name for Kamieskroon
 (11203–11234)
 11223 *Lachenalia hirta* Thunb.
 I'Aus in collibus 2 600'
 13.IX.1897 *R.Schlechter 11223*
Lachenalia hirta Thunb. (BM, G, GRA, K, PRE, Z).
- 19–20/9/97 Concordia (11313–11344)
 11322 *Lachenalia concordiana* Schltr. n. sp. MS.
 Concordia in collibus 3 100'
 19.IX.1897 *R.Schlechter 11322*
Lachenalia concordiana Schltr. ex Barker (B, BM, G, GRA, K, LD, Z).

- 21/9/97 Leeuwpoot. Leeuwpoot is about nine miles N of Concordia (11345–11353)
- 11366 *Lachenalia xerophila* Schltr. n. sp. MS.
 Leos Poort in collibus 3 000'
 21.IX.1897 *R.Schlechter 11366*
Lachenalia xerophila Schltr. n. sp. MS. (BM, BOL, G, K, LD, Z).
 A new species? Not yet published.
- 21/9/97 Goechas. Goechas is a couple of miles N of Leeuwpoot (11365–11379)
- 11366 *Lachenalia*
 Goechas in collibus 3 000'
 21.IX.1897 *R.Schlechter 11366*
Lachenalia xerophila Schltr. n. sp. MS. (GRA)
 This locality fits in better into the numbering in Jessop's list than Leeuwpoot in the former. A new species? Not yet published.
- 23/9/97 Steinkopf (11381–11383)
- 11383 *Lachenalia namaquensis* Schltr. n. sp. MS.
 Steinkopf in collibus 2 800'
 23.IX.1897 *R.Schlechter 11383*
Lachenalia namaquensis Schltr. ex Barker (B, BM, BOL, G, GRA, K, LD, PRE, Z).
- 25/9/97 Karoechas (11384–11394)
- 11384 *Lachenalia polypodantha* Schltr. n. sp. MS.
 Karoechas in collibus 3 000'
 25.IX.1897 *R.Schlechter 11384*
Lachenalia polypodantha Schltr. ex Barker (B, BM, GRA, K, LD, PRE, Z).

**FREYLINIA VISSERI EN FREYLINIA DECURRENS (SCROPHULARIA-
CEAE): TWEE NUWE SPESIES VAN DIE SUID-WES KAAPLAND**

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UITTREKSEL

Freylinia visseri E. J. van Jaarsveld en *Freylinia decurrens* Levyns ex E. J. van Jaarsveld word beskryf. *F. visseri* het reeds uitgesterf in die natuur en is deur mnr. Visser van totale uitwissing gered.

ABSTRACT

**FREYLINIA VISSERI AND FREYLINIA DECURRENS (SCROPHULARIA-
CEAE): TWO NEW SPECIES FROM THE SOUTH WEST CAPE**

Freylinia visseri E. J. van Jaarsveld and *Freylinia decurrens* Levyns ex E. J. van Jaarsveld are described. *F. visseri* is already extinct in nature but has been saved by Mr. Visser from total extinction.

***Freylinia visseri* E. J. van Jaarsveld, sp. nov.**

Differt a *Freylinia undulata* Benth. quia est multo maior, erectus, stoloniformis, multicaulis, ad 3 m altus frutex; foliis linearibus oblanceolatisque, recte expansis, leviter revolutis, 20-30 mm longis; corolla purpurea, infundibulari, 20-25 mm longa, 3-4 mm lata ad basim; lobis effusis; staminodio gracili, piloso, errigente e basi corollae tubi; capsula 10 mm longa et 7 mm lata.

Typus: Hermanuskraal, Veld drift (-CD), 20 November 1947, *F. G. H. Visser s.n.* NBG 46515 (NBG, holotypus).

'n Regopgroeiende veelstammige haarlose immergroen struik tot 3 m hoog. Stingels uitlopervormend, lank en reguit en yl vertak aan basis; ouer stingels blaarloos, grysbruin en roedevormig; jonger stingels gerib as gevolg van die blaarbasis wat oorlopend op die stingels is. Blare regopgroeiend-spreidend, afwisselend of soms in kranse, half-sittend of gewoonlik met 'n kort blaarsteel 1-2 mm lank; lineêr omgekeer eiervormig, toegespits en gemukroneer aan punt en wigvormig aan basis, 15-30 mm lank en 3-5 mm

Vir publikasie aanvaar 23 Julie, 1982.

breed, gaafrandig en effens revoluu, liggroen; hoofaar prominent, meer so uitstandig aan ondervlak; syare onduidelik. Bloeiwyse eindstandige veelblommende raseem 30–60 mm lank of 'n los pluim tot 190 mm lank. Blomme in 1–3 blommende kortgesteelde byskerms 3–4 mm lank; byskerms afwisselend, teenoorstaande of soms in kranse van 3; skutblare 2–4 mm lank, soos die loof blare. Bloeisteel 3–4 mm lank. Kelk 4 mm lank, segmente oorvleuelend, eivormig en skerppuntig. Blomkroon pers-kleurig 20–25 mm lank. Kroonbuis tregtervormig 17 mm lank, 2–4 mm breed aan basis en verwyd gelydelik na 4–5 mm waar buis 5-lobbig eindig, effens donsharig aan die binnevlak; lobbe rond ongeveer 5 mm lank, spreidend. Meeldrade 4 didinamies, ingebed in boonste helfte van kroonbuis; helmtrade oorlopend op kroonbuis, helmknoppe ongeveer 1 mm in deursnee, stuifmeel roomkleurig. Staminodium ongeveer 10 mm lank, donsharig en ingebed aan die basis van die kroonbuis. Stamper 15 mm lank, speldekopvormig. Vrugbeginsel elipsoïed 2-sellig, 1,5 mm lank. Kapsule ongeveer 10 mm lank en 7 mm in deursnee.

Blomtyd: September tot November

HABITAT EN VERSPREIDING

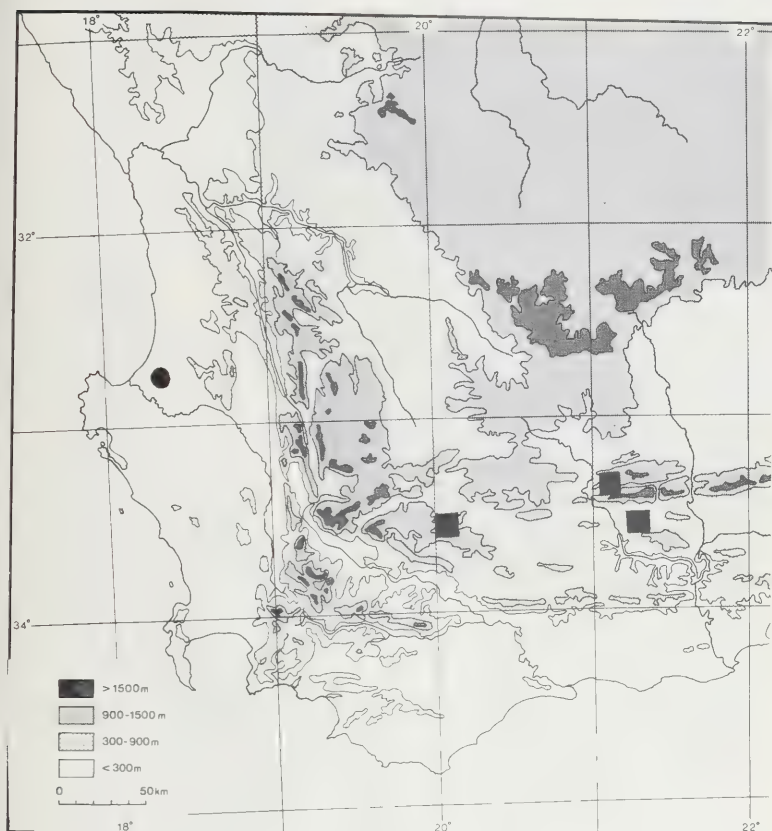
Hierdie plant het uitgesteef in die natuur maar het oorspronklik voorgekom in die Strandveld van die westelike Kusstrook (Acocks Veldtipe Nr. 34) op die plaas Hermanuskraal (tans tussen Weglopersheuwel en Markus-kraal) ongeveer 10 km vanaf die kus. Die plante is vernoem na mnr. Floors Visser, wat die plant in November 1947 versamel het. Volgens mnr. Visser, het die plant net op daardie plaas voorgekom, op 'n oorblywende "eielandjie" in die Koring-saailand. Die grond was te swak om te verbou as gevolg van die onderliggende potklei onder die sand, en daarom dat hierdie lappie grond beskermend gebly het. Dié lappie grond was ook effens hoër as die saailand. Later, in 1954, is hierdie lappie grond ook verbou, waarby hy 4 lote op Grootklipfontein (Aurora) kom plant het, en wat hierdie spesie van uitwissing gered het.

Volgens mnr. Visser, het die volgende plante ook in assosiasie met *F. visseri* voorgekom: *Putterlickia pyracantha*, *Tetragonia fruticosa*, *Salvia africana*, *Euphorbia mauritanica* en 'n Restionaceae spesie.

Die skrywer en mnr. Graham Duncan het die gebied by Velddrif baie goed gefynkam en daar kon geen spoor van nog populasies gevind word nie. Reënval in die gebied is ongeveer 300 mm per jaar.

BESPREKING

Freylinia visseri is verwant aan *Freylinia undulata* Benth. maar kan maklik onderskei word deur die groter en meer regop groeiwyse (3 m). Die



G.P.-S (L).

FIG. 1.
Map showing distribution of *Freylinia* species.

● *F. visseri*
■ *F. decurrens*

blare is lynvormig omgekeer eiovormig en 20–30 mm lank. Die blomkroon is 20–25 mm lank en 3–4 mm breed aan die basis en die blomtyd is van September tot November. In 'n nota aangeheg aan mnr. Visser se eksemplaar, lewer wyle Professor Compton die volgende kommentaar:

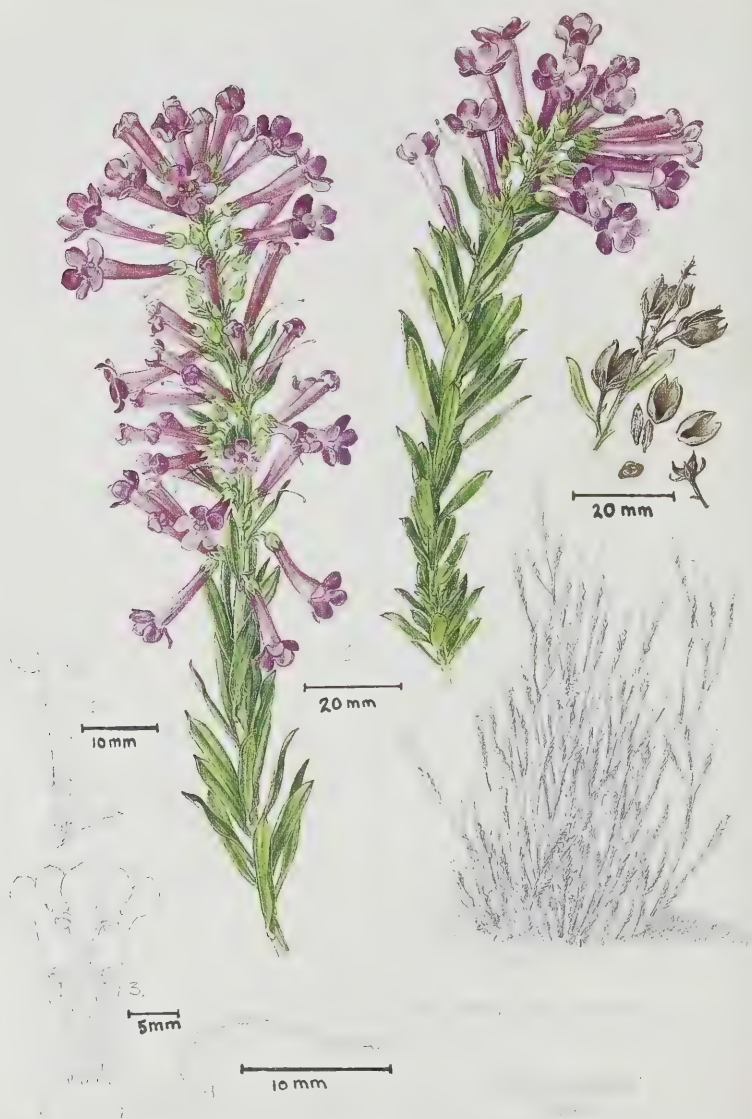


FIG. 2.

Freylinia visseri, sp. nov. NBG 46515 (NBG), 1. bloeiwyse; 2. blomkroon; 3. lengtesnee van die blomkroon; 4. stamper; 5. vrugkapsule.

“This seems to be *Freylinia* related to *Freylinia undulata*. A striking feature is the slender pilose staminode rising from the very base of the corolla tube; this not being found in the flowers of *Freylinia undulata*, *F. lanceolata* and *F. decurrens*”.

Die plante het plaaslik as Suurlat bekendgestaan. Gelukkig kweek die plante maklik van steggies en uitlopers en is reeds by Kirstenbosch Botaniese Tuin gevestig. Hierdie spesie is 'n baie aantreklike tuinstruik en behoort goed in moeilike sanderige tuine na aan die kus in suid-Kaapland te aard.

EKSEMPLARE ONDERSOEK

KAAPLAND—Ex Hort: Kirstenbosch Botaniese Tuin 213/82, *E. J. van Jaarsveld* 5677 (Mnr. Visser se tuin by Grootklipfontein Aurora, 19/9/80). (NBG).

Freylinia decurrens Levyns ex *E. J. van Jaarsveld*, sp. nov.

Differt a *Freylinia visseri* van Jaarsveld foliis distinctis coreaceis canaliculatis et effusis subrecurvatis. Frutex glaber. 1–2 m altus; foliis verticalibus quinquefariis, magis aggregatis in extremitatibus ramorum; corolla purpurea, infundibulari, 16 mm longa; lobis albis revolutis recurvis; capsula 10–12 mm longa et circa 5 mm lata.

Typus: Suid van Ladismith (-CB), Julie 1928, *M. R. Levyns* 2729 (BOL, holotypus).

'n Regopgroeïend veelstammige haarlose immergroen struik, 1–2 m hoog. Stingels uitlopervormend, bruingrys, vertak; jonger stingels ligbruin vierkantig, gerib as gevolg van die blaarbasis wat oorlopend op die stingels is. Blare liggroen, meer gedronge aan die punte van die takke, in 5 vertikale rye, kransgewys of afwisselend, leeragtig, spreidend, lineêrlansetvormig, onderskeidend gekanaliseer en teruggekrom, skerppuntig en gemukroneer aan die punt, wigvormig aan basis 12–30 mm lank en 2–3(4) mm in deursnee, halfsittend of kort gesteeld 1–2 mm, hoofaar prominent, meer so aan ondervlak. Bloeiwyse eindstandig; veelblommende raseem 30–60 mm lank, of 'n pluim tot 150 mm lank. Blomme in 1–3 blommende kort-gesteelde (2 mm) byskerms. Skutblare geleidelik oorlopend in loofblare, blomsteel 2 mm lank. Kelk 5 mm lank, segmente oorvleulend eivormig, skerppuntig en 5 mm lank. Blomkroon 16 mm lank, perskleurig, lobbe wit. Kroonbuis tregtervormig, 12 mm lank, silindries, 2.5 mm breed aan basis en verwyd geleidelik na 4 mm, donsharig aan basis van binnevlak, kroonlobbe teruggekrom en revoluu, rond, ongeveer 5 mm lank. Meeldrade 4 didinamies, ingebed in boonste helfte van kroonbuis, helmdrade oorlopend op kroonbuis; helm-

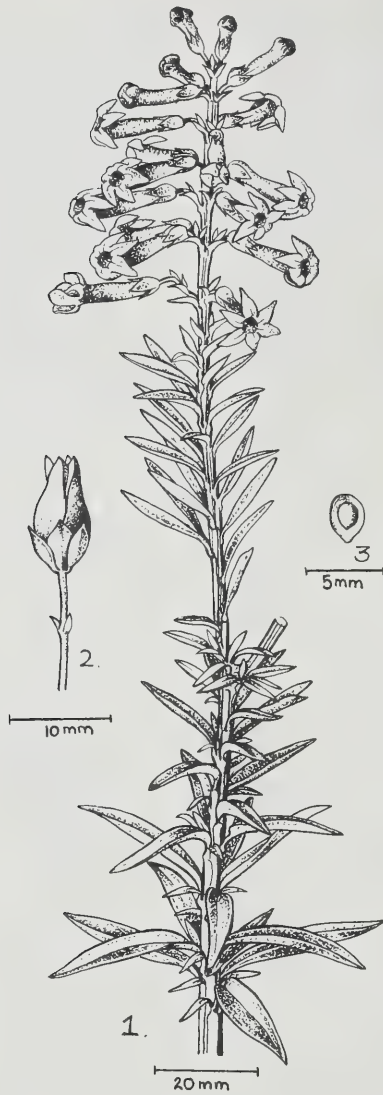


FIG. 3.

Freylinia decurrens, sp. nov. E. J. van Jaarsveld 5769 vanaf Pampoenkloof, Montagu (NBG). 1. die stingel met die bloeiwyse; 2. die kapsule; 3. die saad.

knoppe ongeveer 1 mm in deursnee, stuifmeel roomkleurig. Stamper 12 mm lank; stigma speldekopvormend. Vrugbeginsel ellipsoïed 2-sellig, 1 mm lank. Kapsule ongeveer 10–12 mm lank en 5 mm breed. Saad orbikulêr met membraanagtige vlerk, 2–3 mm in deursnee.

Blomtyd: Junie tot September.

HABITAT EN VERSPREIDING

Freylinia decurrens kom voor in die Karoo-agtige gebroke veld (Acocks Veldtipe Nr. 26) en die habitat is droog. Reënval kom hoofsaaklik in die winter voor en wissel van 200–300 mm p.j. Die plante kom in bergagtige, goedgedreineerde gebiede voor, gewoonlik aan suidelike hellings tussen rotse en klippe.

Die skrywer het plante versamel in 'n rotsagtige, skalieryke omgewing. 'n Enkel plant, in dieselfde omgewing, is ook in 'n stroombedding versamel, waar dit saam met *F. lanceolata* gegroei het (Pampoenkloof, Montagu).

BESPREKING

Freylinia decurrens is verwant aan *F. visseri* en *F. undulata* maar is maklik onderskeibaar deur die leeragtige, lineêrlansentvormige, gekanaliseerde teruggekromde spreidende blaartjies en die teruggekromde kroonlobbe.

Freylinia decurrens is eerste versamel in Julie 1928 deur mev. Levyns wat dit as 'n nuwe spesie herken het en dit toe die manuskripnaam *F. decurrens* toegeken het. Dit is 'n aantreklike tuinstruik wat maklik van steggies kweek en behoort goed in droë tuine in winterreënvalgebeide aan te pas.

EKSEMPLARE ONDERSOEK

KAAPLAND—3321 (Ladismith): Kruiwagendsdrift, Klein Swartberg (-AC), 1 Julie 1959, *J. M. Wurtz 1670* (BOL).

—3320 (Montagu): Baden Hillside (-CA), 22nd September 1946, *R. H. Compton 1834* (NBG).

BEDANKINGS

Mnr. Winter, Kurator van Kirstenbosch Botaniese Tuin, wat dit vir my moontlik gemaak het om die plante na te spoor.

Dr. Rourke en mevrou Fairall van die Compton Herbarium word vir hul hulp bedank.

Mnr. Norval Geldenhuis word vir die latynse beskrywing bedank en mnr. Grobler en mej. Bosman vir nasien van die manuskrip.

Mev. Ward-Hilhorst word bedank vir die puik illustrasies.

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A REVIEW OF DECOMPOSITION AND REDUCTION AND OF SOIL ORGANIC MATTER IN TROPICAL AFRICAN BIOMES

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ABSTRACT

Decomposition and reduction processes are described in relation to the chief causative organisms, namely, termites, ants, earthworms, dung beetles and micro-organisms while the effects of both inter- and intra-seasonal droughts on these processes and that of fire as a reducer agent are also discussed. Finally, a review of the humus status of tropical and subtropical soils, and non-forest ones in particular, is presented with particular reference to the possible reasons for the low soil organic matter contents generally found in such soils. It is concluded that further research in this field is required.

UITTREKSEL

'N OORSIG VAN DIE AFBRAAK EN REDUKSIE EN VAN GROND ORGANIESE INHOUD VAN TROPIESE BIOME IN AFRIKA

Afbraak en reduksie prosesse word beskryf in verhouding tot die hoof oorsaaklike organismes, naamlik, termiete, miere, erdwurms, miskruiers en mikro-organismes terwyl die invloed van beide inter- en intraseisoens-droogtes op hierdie prosesse sowel as vuur as 'n reduseerder ook beskryf word. Ten slotte, word die humusstatus van tropiese en sub-tropiese gronde, en nie-woud gedeeltes veral, aangegebied met spesiale verwysing na die moontlike oorsake vir die lae grond organiese materiaalinhoud wat algemeen aangetref word in sulke gronde. Die gevolgtrekking word gemaak dat verdere navorsing in hierdie veld nodig is.

INTRODUCTION

In tropical and subtropical biomes, there are three possible fates for primary production that dies before being consumed by an animal. It may be consumed when dead (dead matter consumption and reduction), be decayed by micro-organisms (decomposition; also referred to as "oxidation") or be burnt. After a brief consideration of litter input, the processes of reduction and decomposition are dealt with in this review while herbivory (consumption) and fire are discussed to a much lesser extent. Dead organic matter plays a major rôle in determining the structure and function of an ecosystem by acting as a nutrient reservoir for intrasystem cycling and as an energy source for heterotrophic organisms (Singh & Gupta, 1977). Rates of decomposition and reduction and consequently the rate of nutrient release, eluci-

Accepted for publication 16th August, 1982.

dition of which is the usual reason for such studies, depend on the species concerned and abiotic factors of the environment as will be pointed out below. Aspects of the build-up of humus, an end-product of these processes, is an enigma in tropical and subtropical biomes and is therefore given prominence in a section of this review.

Species of termites, ants, earthworms, dung beetles, Coleopteran larvae, millipedes and cockroaches are the macrofaunal components identified as making the greatest contribution to dead matter breakdown and consumption to tropical and subtropical biomes. The relative importance of these groups varies from one biome type to another. Microbial activity is at least as important as the macrofaunal elements in the decomposition and reduction process and under tropical non-forest conditions has major differences in mode of functioning from both temperate and tropical forest ecosystems. Aspects of these differences are elaborated below. An outline of the processes involved in dead matter consumption and decomposition is also given.

In view of the paucity of data, a very wide definition of tropical and subtropical biomes is adopted although the geographical coverage of the review is heavily biased towards Africa. More emphasis is placed on botanical aspects than zoological although the subject is truly multidisciplinary, a reflection on the author's background.

LITTER DYNAMICS

In general modelling terms, inputs to the decomposition and reduction system are independent of the standing crop of dead organic material and outputs are proportional to, and therefore dependent on, the amount of the standing crop. The net rate of change in energy or material stored in an ecological system, or its parts, equals the rate of input minus the rate of loss (Olson, 1963). From one-year litter bag trials at the South African Savanna Ecosystem Project study site, Nylsvley, in the Northern Transvaal, Morris *et al.* (1982) reported the following half lives (time for the decomposition of half a given amount of litter) for freshly-fallen tree leaves: *Ochna pulchra* 5.5 years, *Burkea africana* 5.1 years and *Terminalia sericea* 2.9 years. Vegetative material of the two common grasses, *Eragrostis pallens* and *Digitaria eriantha*, both had half lives of 0.7 years. Values of k , the annual decomposition constant, for Nylsvley range from 1.20 for grass litter to 0.13 for *Ochna pulchra* leaves in litter bags. The decomposition constant for tree leaf litter at Nylsvley is between 0.13 and 0.33. Much faster rates are recorded by Malaisse *et al.* (1975): in miombo woodland, k varies from 1.11 to 1.32 (the latter in the presence of fire) and k is 1.40 in dry evergreen forest. Rates from 2.0 to 4.85 are quoted for mixed dry lowland forest. In Senegal, Bille

(1978) records values for the monthly rate of disappearance of dead matter ranging from 0.37 to 0.64 (at the end of the rainy season) to 0.09 to 0.15 (during the dry season). Where an annual burn is part of the environment, such as at Lamto (Côte d'Ivoire) such calculations are not appropriate and values are not available. Ashton (1975) records half lives of 0.82 and 1.98 for leaf and total litter, respectively, from *Eucalyptus regnans* forest near Melbourne, Australia.

PROCESSES

Generalisations about dead matter consumption and decomposition processes in tropical and subtropical biomes are difficult to make as the range of patterns within such biome types is almost as great as the range between them. The best data available on these patterns are from Lamto, a moist, rather atypical "savanna"¹ adjacent to tropical rainforest (Lamotte, 1977 and 1978; Anon, 1979a). At Lamto, dead matter consumption and decomposition are largely due to the activities of termites, earthworms and microarthropods (Lamotte, 1975 and 1979). Ants are also involved, as well as myriapods and the underground larvae of Coleoptera. It seems that drier biomes, as exemplified by Nylsvley, show a markedly different pattern with reducers being more important relative to decomposers, termites of great importance and earthworms unimportant (Morris *et al.*, 1982; Huntley & Morris, 1982). At Lamto, animals account for nearly 15% of the mineralisation of organic matter while the mechanical action of these populations (soil movement and organic matter transformation) seem even more important than mineralisation (Anon, 1979a). The individual rôles of important agents are discussed below.

Of the key ecological processes operating in tropical and subtropical biomes, the inter-seasonal soil moisture deficit and fire have certain, probably rather minor, influences on dead matter consumption and decomposition, making these processes rather different from those in other biomes. In all but the most moist of such biomes, the intra-seasonal intermittent desiccation of litter in the wet season, on the other hand, may have considerable ramifications on the processes.

Termites

Termites are inhabitants of tropical, subtropical, semi-arid and, to some extent, warm temperate regions (Allison, 1973; Wood, 1976). The vast ma-

¹ On the advice of a referee, the term "savanna" has been avoided except where used in quoted literature as the term in the African context was unanimously recommended as being unacceptable to botanists and ecologists as long ago as 1966 and the resolution has been endorsed by many scientists down ensuing years.

jority of research on decomposition processes has, however, been done in cool temperate regions (Anderson & Macfadyen, 1976) and although a few species of termites occur in these regions they have little impact on decomposition processes. Where termites are abundant, their activities are sufficient to generate new pathways of decomposition, in comparison with temperate regions (Wood, 1976). According to Russell (1961), termites in tropical soils seem to be the predominant animals affecting the soil and the plant. The rôle of humus-feeding species in pedogenesis is to produce, through their faeces, a more stable organic matter substrate for the physiochemical and bacterial agents of degradation (Malaisse *et al.*, 1975).

On the basis of diet, there are three kinds of soil-inhabiting termites: wood feeders, fungus growers and humus feeders (Harris, 1955). At Lamto, foraging, humivore and fungus-growing termites are the three main groups (Lamotte, 1975). Harvester termites are an important ecological group which feed on living and dead grass while other termites either forage for or live in dead wood, or even living trees. Species differ greatly in their diet, specificity and habitats and most typical non-forest biome sites have a diverse termite fauna. At least 20 species, for example, have been identified at Nylsvley (Ferrar, 1982a & 1982b) and 36 species are recorded from Lamto (Wood & Sands, 1978).

The food of termites consists of plant material of all kinds, including wood, grasses, herbs and roots, in the range from living plants to decomposed plant remains mixed in mineral soil. Soil-feeding has been adopted as a specialised habit by many species of higher termites. In tropical non-forest regions, where levels of organic matter are notoriously low (Wood, 1976), termites may be partly responsible for reducing organic matter content. Cellulose is the main carbohydrate utilised by termites that feed on wood or vegetable matter. Digestion in most species is brought about by flagellates or bacteria that live in the intestines and secrete cellulase. The five families of lower termites (about 25% of known species) have flagellates while the higher termites (Termitidae) have no flagellates but do have bacteria (P. Ferrar, pers. comm.) The species that do utilise organic residues do so very completely and markedly hasten the decomposition process (Allison, 1973).

There are many common termite species which move large quantities of soil, sometimes ingesting much of what they move, bringing grass and other plant material into the soil and burrowing and tunnelling through the soil in the process (Russell, 1961). Unlike other soil animals which deposit faeces within the soil where they are available to micro-organisms and coprophagous invertebrates, termites use their excreta to construct certain regions of the nest or to construct fungus combs which are further utilised as food (Wood & Sands, 1978). Thus organic material and the nutrients it contains are collected from a wide area and concentrated largely in the central region

of the nest system. Through the concentration of nutrients in nests, termites contribute to the patchiness of nutrient distribution in soils. This process has an impact on the vegetation, resulting in greater species diversity and stronger patterns (Malaisse, 1978). Trapnell *et al.* (1976) report the lack of significant change in nitrogen and carbon in soils under various fire regimes in Zambia. After 23 years without burning the organic matter content had not changed appreciably. At the same time they report that termite mound material had over three times the organic carbon content of adjacent surface soil. A proportionally still greater increase in exchangeable bases is reported. Wood- and litter-consuming species are considered responsible for the limitation of humus sources under fire protection. Lee & Wood (1971) and Wood & Sands (1978) also report that some termite mounds have concentrations of organic matter higher than the soil from which they are constructed.

The distinction has, however, to be made here between the humus-feeding species which build mounds with an excreted paste and the wood- and litter-feeding large-mound builders which construct their foraging passages and spires with soil particles carried up from subsoil far below the surface and bound by salivary matter (Trapnell *et al.*, 1976). Analyses of mound material with organic matter and nutrient contents lower than adjacent top soil but closely similar to the subsoil are summarised by Wood & Sands (1978). Subsoil is brought to the surface from a depth of from one to more than three metres (Allison, 1973). The large mounds that may reach a height of 10 metres provide microclimates and shelters for a wide range of plants and animals within the "savanna" matrix (Malaisse & Anastassiou-Soquet, 1977).

Ants

In South America, ants replace termites in some of the scavenging and reduction rôles that the latter occupy in Africa. Data are available from Surinam, Brazil and other tropical South American countries. It is reported by Bucher (1982) that ants are of considerable importance in the Chaco as a result of their great abundance and degree of ecological diversification. Some species of leaf-cutting ants are specialised as detritus feeders, particularly taking fallen leaves and insect frass. They are extremely abundant in the Chaco dry woodlands and as they carry litter underground for fungus-growing, they also have an important rôle in nutrient cycling and redistribution. Ants are a relatively minor contributor to soil formation and organic matter decomposition according to Allison (1973). He considers that their chief rôle in soil formation lies in the transport of subsoil to the surface.

The rôle of ants in ecosystems is reviewed by Petal (1978). Rôles similar to those described above for termites are reported although they appear to occupy a wider range of niches than termites. Accumulation of nutrients and

organic matter in nests as well as the opposite effect are found (Petal, 1978). Description of the important rôle of ants as consumers is beyond the scope of this review.

Earthworms

Earthworms are intolerant of drought and frost and hence dry sandy soils and thin soils overlying rock are not usually favourable environments for them (Anon, 1979a). They also need reasonably aerated soil and can only flourish in soils well provided with organic matter (Russell, 1961). As conditions in drier tropical and subtropical biomes are not often suitable for earthworms, it is not surprising that they are seldom common except in moist habitats, such as found at Lamto, where soil organic matter content is low (J. C. Menaut, pers. comm.). Some soil-dwelling termites appear, in fact, to be the tropical analogue of the earthworm (Russell, 1961).

Dung beetles

The main group of dung beetles involved with the reduction of dung is the Scarabaeinae (Coleoptera), which are only active in fresh dung. The attack on dried dung by termites appears to be a characteristic feature of tropical and subtropical non-forest biomes, judging from evidence from South America, Lamto and Nylsvley. Dung beetles attack dung in three main patterns, of which the best known is perhaps by beetles fashioning lumps of fresh dung into spherical balls and rolling them away some distance for burial (Bornemissza, 1979). More common, but less well-known, are those which bury fresh dung on the spot by digging tunnels which may end in chambers. The third, and insignificant group, excavate old dung pads.

The lack of an indigenous Coprophagous fauna in the Australian hinterland for the efficient treatment of cattle dung is worth noting. Although there are 250 species of dung beetle in Australia, very few find the soft cow pads with their high water content attractive (Bornemissza, 1979). The problems arising from dung pollution in the absence of these organisms in Australia is a good example of the essential rôle decomposers and reducers have in a system, whether natural or artificial.

Micro-organisms

The complex relationships between groups of micro-organisms and specific environmental factors under tropical conditions are reviewed by Mohr *et al.* (1972). Moisture, access of air, temperature, acidity and the supply of food materials have different but rather marked influences on the number of micro-organisms as well as their activity. Generally, conditions appear to favour bacteria in the lower warmer tropics while fungi predominate in cooler climates found at higher altitudes.

Fire

In non-forest tropical and subtropical biomes, fire is an important, if not the most important, agent of dead matter "respiration", in comparison with its minor influences on consumption and decomposition. The subject of fire in these biomes is beyond the scope of this review and only some aspects directly related to decomposition and reduction will be mentioned.

The major effect of fire is the removal of living material (which is potential input to the dead organic matter compartment), standing dead plant parts and litter and the associated release of organically bound mineral elements in the form of ash. Fire will also kill a proportion of the organisms in the remaining litter and will make post-fire soil and litter temperatures more extreme. Blackened surfaces will absorb more heat while reduced shading of the surface by plants and litter will result in raised maximum day-time and lowered minimum night-time temperatures. Decomposer organisms can be expected to recover from fire fairly quickly while reducers, through a decrease in the quantity and quality of their food source, will recover more slowly.

If fire is excluded from a vegetation type in which fire is normally a major reducer, there will be a build-up of dead organic material until the steady state standing crop is reached. The steady state is approached asymptotically and the final amount may be considerable. Such a system has relevance to the frequency of fire in that a vegetation prone to fire will have a high primary production and either a low herbivory rate or a low dead matter consumption and decomposition rate, or both.

EFFECTS OF SOIL DROUGHT

Inter-seasonal drying

Inter-seasonal drying is likely to have effects that are either too broad or too subtle to be easily identified. In wetter biomes, organisms such as earthworms are able to survive such drying whereas in drier biomes, dry periods within the wet season (see below) will have marked effects confounding the effects of the dry season. Micro-organisms are unlikely to be inhibited during the wet season by the necessity to survive the dry season in spore form. There may, however, be certain effects on the timing of nutrient release attributable to drying out of litter, possibly enhancing leaching at the beginning of the subsequent wet season.

Intra-seasonal drying

Considerable effects may result from the frequent dry periods during the wet season, during which litter dries out to a great extent. This is a major

contributory factor to the slow decomposition rate recorded for non-forest tropical biomes. Micro-organisms are not only inactive in dry litter but have to build up in numbers when the litter is re-moistened. This pulse activity may itself influence the micro-organism species present as they will usually be present in small numbers within the litter and will therefore rarely be competing with each other. The wetting-drying cycle within a season may have appreciable effects on nutrient release not observed in a continuously-moist litter. If nutrients, and especially nitrogen, are more easily washed out of dead micro-organisms than from living ones or dead plant matter, then there would be a pulse of nitrogen leached at the start of each rainy period and rain season.

The slow rate of decomposition in drier tropical and subtropical biomes is likely to have a large number of effects on dead matter consumption and decomposers. Just as secondary production in different biomes has been characterised as reducer- or consumer-dominated, dead matter consumption and decomposition in drier biomes is reducer-dominated with a relatively minor rôle played by decomposers. The opposite holds in moist biomes, resulting there in low standing crops of litter. In drier biomes, reducer organisms, with superior water conservation relative to micro-organisms, are able to survive dry periods and play an important rôle in dead matter consumption and decomposition. Termites have a particularly effective water conservation system. In moister ecosystems, the termite moisture control system (tunnels built for foraging) becomes a handicap as it requires considerable energy to maintain. Other, more mobile reducers, take over and decomposers will be better able to decay material.

SOIL HUMUS STATUS

The relatively slow decomposition rate noted for dry tropical and subtropical biomes makes it difficult to explain the documented absence of a well-defined humus layer in the soils of drier biomes (Anon, 1978; Greenland & Nye, 1959; Vine, 1968). In moist biomes including tropical and subtropical forest, high soil and litter moisture contents and high temperatures result in the rapid breakdown of dead organic material and the formation of a distinct humus layer. In drier biomes, one or both of these two factors may be inoperative while, of course, primary productivity and thus input to the litter compartment are also lower. Although the breakup of litter is rather slow, once it has broken up and is in small fragments, either on the soil surface or mixed into the topmost soil layer, the moisture conditions of the material become much more favourable for rapid decomposition. Fresher material on top of small fragments protects the latter from desiccation to a certain degree and soil will usually have far better moisture retaining pro-

perties than litter so that once the fragments have become incorporated into the soil, decomposition is facilitated. The process is further accelerated by high temperatures relative to temperate region ecosystems. It is also suggested that leaching and runoff following tropical downpours could account for the absence of a humus layer. Light humus particles on the soil surface could also be blown away by wind erosion. Some apparent contradictions and gaps in our knowledge with regard to soil humus status became apparent during the writing of this review, these being presented below with the intention that they spur further research. Both Anon (1979a) and Rodin & Bazilevich (1967) stress that very little research has been undertaken to date in this important field, with particular reference to tropical and subtropical areas.

Soil humus is of great importance in the soil-formation process and in soil fertility maintenance (Anon, 1979b). Mohr *et al.* (1972) consider soil organic matter to be the dominant factor in soil formation. As well as being a valuable source of nutrients, particularly nitrogen, the organic matter in tropical and subtropical biome soils is important in maintaining their structure, water-holding capacity and resistance to erosion and in providing much of their cation exchange capacity (Jones, 1973). Organic matter influences physical and chemical properties of soils far out of proportion to the small quantities present, accounting, for example, for at least half their cation exchange capacity (Brady, 1974). Within the tropics, soil organic matter has been shown to increase with increasing altitude, increasing rainfall and decreasing temperature (Jones, 1973). Nye & Greenland (1960) note that in tropical soils, decreasing rainfall is correlated with lower organic matter content. The optimal conditions for mineralisation of plant residues are found where temperatures are high and soil moisture satisfactory, such as in the low hilly regions of the tropics, and consequently little organic matter will remain in its original or humified state (Mohr *et al.*, 1972). On the other hand, at higher elevations organic matter will accumulate; the higher the elevation the more humus remains (Mohr *et al.*, 1972).

The formation of humic substances is due to complex transformations of the original organic residues and the process and products are described as follows by Kononova (1961). In forming humus, the enzymatic activity of both micro-organisms and macrofaunal elements are important. A first group of substances in soil humus, derived from decomposing plant and animal residues and being products of their decomposition and re-synthesis in micro-organisms, consists of various nitrogenous and non-nitrogenous organic compounds belonging to well-known groups of organic chemical compounds such as proteins, carbohydrates, organic acids, fats, waxes and resins. A second and larger fraction consists of humic substances. Because of the peculiarity of their nature they cannot be related to any existing

groups of organic chemical compounds. Their nature, origin and properties are not yet fully understood. Schnitzer & Khan (1972) state that the mode of formation of humic substances has been the subject of much speculation and list four hypotheses which have been proposed for their synthesis. They conclude that it is difficult to state which of the four hypotheses (plant alteration, chemical polymerisation, cell autolysis and microbial synthesis) is the more valid one.

Greenland & Nye (1959) have found that decomposition constants for lowland (tropical) forest soils are about three times larger than those of non-forest tropical biome soils. They consider that the low rate of decomposition in the latter soils is probably connected with the repressive effect which grasses exert on humus mineralisation, as shown by the very low levels of nitrate in such soils. For comparison, constants for temperate-zone oak and pine forests have humus-carbon decomposition constants closely similar to those for highland tropical forests. The loss of organic matter caused by high rates of respiration at high soil temperatures is not always the primary cause of low organic matter contents in tropical soils (Greenland & Nye, 1959). The effects of low returns of organic matter due to burning and soil erosion are also very important in their estimation. Nye & Greenland (1960) note that burning in tropical biomes reduces the buildup of humus in the topsoil by reducing the amount of litter supplied to the soil organisms. The organic matter content of the surface horizons of non-forest soils is considerably lower than that of forest soils because of the reduced additions of organic matter from the vegetation. The exchange capacity is consequently lower (Nye & Greenland, 1960).

Greenland & Nye (1959) have pointed out that in the tropics the relationship between soil organic matter and vegetation type is the reverse of what is found in the temperate zone (see also Jenny, 1950; Greenland & Kowal, 1960; Sanchez, 1976). In the tropics, much the largest addition of organic matter to the soil takes place under forest vegetation and the soil organic levels tend to be greater than under non-forest vegetation types. In the temperate zone, on the other hand, soil organic matter production tends to be greater on grassland areas and it is the grassland soils which have the highest levels of soil organic matter. A factor seldom considered in such general comparisons is that input from primary production should include both above- and below-ground plant components, where the latter are very difficult to quantify.

The organic matter content of certain tropical soils, especially the forested ones, is low, according to Allison (1973), primarily because of the high temperatures and rainfall, abundant plant and animal life in the soil and the scarcity of inorganic colloids with which the organic matter might combine. Tropical soils can nevertheless support large amounts of vegetation per unit

area because moisture and temperature are suitable for growth while roots bring up nutrients from the subsoil and also intercept nutrients that are being carried down by rainwater.

Allison (1973) also states that organic matter decomposes at a slower rate in the presence of clay than in sand. According to Sanchez (1976), in general, the higher the clay contents, the lower will be the annual decomposition rate of soil organic carbon. This finding is supported by Jones (1973) who also notes that, in general, amounts of organic matter and nitrogen in the surface soils of the West African "savanna" are small. The mean carbon content of 605 well-drained sites was 0.68%. Two important factors governing amounts of organic matter in well-drained soils appear to be the clay content and a moisture factor related to the length of the wet season (Jones, 1973). Multiple linear regression on soil clay content and rainfall accounted for 46.5% and 57.2%, respectively, of the observed variability of soil carbon and nitrogen contents. These findings suggest that the low levels of organic matter in "savanna" soils arise from their predominantly sandy nature and from the relatively low rainfall.

Jones (1973) states that soil organic matter status is undoubtedly closely related to the rate of return of organic residues to the soil and, hence, the type of vegetation. Both vegetative growth and soil microbiological activity are closely controlled by soil moisture. He suggests, therefore, that the length of the rainy season is more important in determining organic matter status than annual rainfall and notes that the essential factor embracing both rainfall and drainage factors is the annual period during which the soil is moist, but unfortunately, such information is rarely available.

The amount of organic material in a soil is the product of a number of diverse factors (Jones, 1973) acting over a period of time on the relative rates of the return of organic residues to the soil and their subsequent breakdown in the soil. In "savanna", Jones considers, it is probably the effective length of the wet season that is more important in determining soil organic matter levels than annual rainfall. Birch & Friend (1956) recognised one major factor, namely rainfall, as having an overall influence on soil organic matter status in East African soils and two minor factors, temperature and clay content, that exercise a modifying influence.

CONCLUSION

In writing this review, some speculation has been included because of a lack of sufficient data relevant to tropical conditions. It is hoped that this paper will, to some degree, provide an impetus for further work. There is obviously a great need for comparative data on the fates of primary production in tropical and subtropical biomes of various types, including detail within the dead matter consumption and decomposition components. Fur-

ther study of soil organic matter levels would also appear to be appropriate as conflicting accounts abound in the literature.

ACKNOWLEDGEMENTS

The contributions made to this review by E. H. Bucher, P. R. Furniss, M. Lamotte, R. G. Noble and B. Pendle are acknowledged. I thank Jane Theaker, J. Bezuidenhout, P. Ferrar, J. L. Hutson, E. Madsen, J. C. Menaut and anonymous reviewers for commenting on the manuscript.

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BOOK REVIEWS

PROGRESS IN BOTANY 43: MORPHOLOGY, PHYSIOLOGY, GENETICS, TAXONOMY, GEOBOTANY, edited by H. Ellenberg, K. Esser, K. Kubitzki, E. Schnepf and H. Ziegler, with pp. xii + 382. Berlin, Heidelberg, New York: Springer-Verlag, 1981. DM 129,00. ISBN 3-540-11091-7.

Progress in Botany, or by its alternative title, *Fortschritte der Botanik*, is not as widely known in South Africa as it should be. In these times of extreme specialisation, and fashions, it is refreshing to find such a collection of reviews which encompasses so many fields of botanical enquiry. Its special usefulness in South Africa is that it draws attention to a very broad spectrum of literature, but particularly to the views of Continental botanists, greatly facilitated by all but two of the chapters being in English.

Some reviews are very condensed, occasionally being little more than notes, whilst the best are very readable summaries spanning the work of a number of years. The references are extensive and up to date. A valuable feature is that many chapters are prefaced by notification of comprehensive new books, major surveys and bibliographies. One of the attractions of this series has been its coverage of less familiar topics, such as the chapter "Special Cytology" by E. Schnepf and the valuable guide to modern ideas in floral morphology by P. K. Endress. Two other contributions are worthy of special notice; thus Stephan Vogel gives a most readable review of work in floral biology since 1979, and Clive Jensen discusses proteins in plant evolution and systematics. A further major and valuable contribution is the wide-ranging review of the systematics and evolution of higher plants by Poppendieck, related in a stimulating and humorous style.

Geobotany, or perhaps more explicitly, vegetation science, is represented by Knapp's survey of concepts and regions, from which however Africa is noticeably absent, and, more specialised, a history of quaternary floras of E. Europe and Central Asia by Frenzel. A well written chapter of wider appeal is that by W. Schmidt, in which he provides an overview of productivity and ecosystem research, including litter and nutrient cycling, and terrestrial and aquatic biomass productivity.

The plant physiology section includes a most informative and comprehensive essay by Amesz on the photosynthetic reaction centre. Ideas on the metabolism of organic acids are examined by Kluge, and of inorganic nitrogenous compounds by Kessler, and secondary products by Schütte. The section is concluded by a short review of recent papers on the metabolism and mode of action of gibberellins, brassinolide and cytokinins. The excellent genetics section is of much wider scope than is usual in purely botanical reviews. Nagel deals with aspects of DNA replication, Binding and Nehls with recombination in higher plants, including protoplast fusion, and Gottschalk with mutation and mutagenesis. The genetics of storage protein and regulation of gene expression is reviewed by Bläich, and Hagemann and Börner give a useful account of advances in plastid inheritance.

Many of the articles, although giving extensive references, are not very critical. Robard's summary of the present state of knowledge of plastid structure and inter-relationship can only be described as terse, and Wöhrmann and Tomiuk hardly do justice to population genetics in a mere ten pages. Whether by intention or not, the

coverage of non-flowering plants with the exception of the fossil forms discussed by F. Schaarschmidt, is scanty. A more serious criticism is the inadequacy of the index: there are too few comprehensive headings, and thus the inclusion of minor interest items, to the detriment of the more probable reader interest, although one must admit that a fairly detailed contents list does to some extent compensate for this. Cross-referencing is very incomplete: thus Umbelliferae and Apiaceae, and Gramineae and Poaceae each refer to separate entries, but not to any in common. More slipshod is to allow "legumes" to stand in the text and index for the family name, and needless to say there are unrelated page references to Fabaceae and to each of the tribes of the Leguminosae! Editorial shortcomings (or is it editorial superfluity?) also lead in places to language awkwardness, and to a number of spelling errors.

Progress in Botany is published annually. The book is offset from typescript but the layout is clear and not unpleasing. There is a strong and attractive binding and by current standards the price should not be regarded as excessive. This is a valuable source of reference and the acquisition of the series can be emphatically recommended to all botanical libraries catering for undergraduate and research interests.

A. R. A. NOEL

BIOLOGY OF PLANTS, by P. H. Raven, R. F. Evert and H. Curtis, with pp. xvi + 686, 3rd edition. New York: Worth Publishers Inc., 1981. US \$19.95. ISBN 0-87901-132-7.

Botany: An Introduction to Plant Biology by Weier *et al.* (Wiley), the 6th edition of which appeared this year, has for the past two decades been one of the best and one of the most popular textbooks of plant biology. However, it most certainly has found a rival in the 3rd edition of *Biology of Plants*, whose 2nd edition predecessor made a successful debut when R. F. Evert of the University of Wisconsin joined as second author.

I would agree with reviewer R. A. Quatrano (*Nature* **295**: 471, 1982) that this text must be "considered as one of the best overall books of general botany." From cover to cover—in fact including the cover which features a reproduction of Vincent van Gogh's *Iris*es—it becomes abundantly clear that considerable teaching and professional experience has gone into a skilfully planned and comprehensively written text. Not only have the personal experiences of Raven and Evert themselves been brought to bear, but also those of many of their colleagues at a number of U.S. universities and even as far afield as Australia, Great Britain, the Federal Republic of Germany and South Africa. About 10 botanists assisted with material, discussions, guidance, and revisions of certain chapters, and nearly 50 others supplied information of various kinds.

Few textbooks can be as well illustrated, either photographically or diagrammatically, and extending colour photomicrography to angiosperm anatomy will ensure that the internal architecture of the plant is viewed afresh. While referring to anatomy, it is fair to point out that Prof. Evert's hand is clearly evident in the presentation of the plant cell, the angiosperm plant body's structure and development, and the morphology generally. This also applies to the detail and superb quality of his light and electron micrographs.

In all there are eight major sections with a total of 30 chapters, four appendices (chemistry, metrication, classification of organisms, geologic eras), a 26 page double-column glossary, and a 17-page four-column subject index. An interesting feature is the *essay*, a factual review of a topical, novel or perplexing phenomenon, written succinctly and italicized for ready identification. Only nine of the 30 chapters have no special essay, but then some have two or more, making a total of 47 (as compared to 33 in the 2nd edition). Chapter 11 on the Procaryotes includes no less than 7 essays on subjects such as genetic engineering, mycoplasmas and viroids, to mention only three. Each chapter, furthermore, is provided with a summary and in most cases also with suggestions for further reading.

When compared to the 2nd edition the new book features a number of improvements, one of which is updated information. Examples: photosynthesis, plant growth regulators, and uptake and transport. Another is the inclusion of information relating to the rapid advancement of biology during the latter part of the 1970's. Examples: recombinant DNA, tumour-inducing plasmids, and lectins. Further improvements concern reorganisation and emphasis. Examples: the chemistry of heredity has been transferred from the plant cell section to that of genetics and evolution; under the section on diversity, the blue-green algae are treated as the cyanobacteria; slime and water moulds are included in an own chapter on heterotrophic protista; emphasis on fossil plants and progymnosperms has been increased.

How might this book serve as a teaching text? This will of course depend on the university system in question. That is, is the curriculum based on a quarter, semester or annual system? Is the course at the introductory, prerequisite, undergraduate or graduate level? Are the students botany or biology majors, or is botany a non-major subject? Is it intended as preparatory to qualifying examinations? The text would be an excellent choice in the traditional three-year, nine-course, double-major degree or the ten-course, single-major degree, where it could be adopted unchanged for Botany 1. (A practical manual and preparation compendium* are also available).

It is a good text for a semester course although here, and more particularly in a quarter course, specific chapters would have to be selected to fit the teaching schedule. However, this should not present problems as the book is so organized that topics can be assigned in any preferred combination of sequences. The text may be less well suited to a system (such as in Sweden) where undergraduate courses are numerous but of short duration. However, even in this case the book offers the student what the system often fails to provide, namely the perception, synthesis and integration of the subject.

It becomes not so much a question as to what level the book should be aimed, but rather one of whether it makes accessible the basic concepts of botany as a dynamic subject. With its depth, which is sufficient for an introductory text, and its encyclopedic breadth of subject matter on which more advanced courses in physiology, morphology and ecology could build, *Biology of Plants* is the kind of text that the student can use even without the guidance of a watchful tutor. For only US \$20,00 it is excellent value and deserves to be widely adopted.

CHRIS H. BORNMAN

* Laboratory Topics in Botany, by R. F. Evert and S. E. Eichhorn, with pp. vii + 176. New York: Worth Publishers, Inc., 1981. ISBN 0-87901-142-4.
Preparation Guide for Laboratory Topics in Botany, by S. E. Eichhorn, J. W. Perry and R. F. Evert, with pp. vi + 168. New York: Worth Publishers, Inc., 1981. ISBN 0-87901-061-4.

PLANT GROWTH REGULATORS: AGRICULTURAL USES, by L. G. Nickell, with pp. xii + 173, 29 figures. Berlin, Heidelberg, New York: Springer-Verlag, 1982. DM 47, 50, approx. US \$22,10. ISBN 3-540-10973-0.

This neatly and well produced book was not written in an attempt to present a comprehensive treatise of all the agricultural uses, or potential uses of growth substances. The author himself stresses in the preface that little attention is given to the basic research which formed the backbone for the successful exploitation of these compounds. Emphasis was rather placed on the positive results which have already been achieved by applying the obtained data in the various fields of agriculture. By setting these terms of references the author succeeded in producing a well laid-out and easy to read text which clearly indicates the tremendous advancements made in the use of plant growth regulators in agriculture over the last decades. Throughout the book the author has succeeded in maintaining a good balance between what has been achieved and what could reasonably be expected in this field in future.

The data presented is covered in 24 chapters. This may seem an unnecessarily large number but these were necessitated by the fact that the author chose to discuss the available information by plant processes which are controlled or affected by the plant hormones. This approach makes the book easy to read and both undergraduates and graduate students should benefit from it. The large number of references to which the author refers should prove of great benefit not only to students but also to intending or existing researchers in this field. For these reasons all teaching and research institutions should have this book on its shelves.

J. VAN STADEN

SILICON AND SILICEOUS STRUCTURES IN BIOLOGICAL SYSTEMS, edited by T. L. Simpson and B. E. Volcani, with pp. xvi + 587, 515 figures and 15 tables. Berlin, Heidelberg, New York: Springer-Verlag, 1981. DM 240, approx. US \$111,80. ISBN 0-387-90592-8.

Siliceous structures occur in many organisms in which amorphous hydrated silica forms cell walls, scales, tests and other skeletal features. In some groups, e.g. the diatoms, the morphology of these siliceous structures form the basis for their taxonomy. Silicon is also required for numerous metabolic processes and is essential for growth and bone development. It is, however, still not clear in what soluble form the silicon is transported and what determines the morphological pattern of siliceous structures.

An international symposium titled, "Siliceous structures and silicon deposition in living organisms", which was held in Richmond, Virginia, U.S.A., during December 1978, initiated the publication of this book.

In the preface to the book the editors state that its publication was undertaken with the dual purpose of bringing together information on the deposition by living organisms of unique skeletal structures composed of amorphous silica, and reviewing recent data on the involvement of silicon in physiological processes. The book also discusses the ultrastructural, physiological and biological aspects of silica.

Attention is focused upon the biological aspects of silica and siliceous structures, with the emphasis on the evolution, phylogeny, morphology and distribution of these structures, on the cellular aspects of silica deposition and on the physiological and

biochemical rôles of silicon. This is the first time that this wealth of data has been compiled into one volume. The field covered is therefore extensive and accordingly it is recommended as a useful reference work for workers in such diverse fields as biochemistry, botany, cell biology, diatomology, marine biology, micropaleontology, phycology, protozoology and zoology.

This is a most informative book and makes stimulating reading. The various chapters are all excellent reviews of the subjects in question. Each chapter is rich in references including the most recent (1980) at the time of going to press. Although the book covers a wide field, the editors should be complimented on their efforts to cross-reference certain features, structures, etc., relevant to the various chapters.

The book comprises 18 chapters written by experts in their relevant fields. In the introduction the editors present a brief survey of the chapters, plus notes and thoughts on morphogenesis of silica in biological systems and the evolution of silica deposition. The bulk of the book is divided into two sections:

1. *Physiological aspects of silicon*. Three chapters. Silica in cellular metabolism of diatoms, germanium-silica interactions in biological systems, and silicon in bone formation.

2. *Siliceous structures: distribution, deposition, ultrastructure and morphogenesis*. Fourteen chapters dealing with algal groups, protozoa, sponges and higher plants.

The general layout of the chapters is good with notes (where applicable) on terminology and procedures. The discussions and the posing of questions make it stimulating reading. There is some overlap between chapters 6 and 7 regarding the characteristics of the diatom cell. Although not detracting from the importance and usefulness of this book it is a pity that throughout chapter 7 the identity of the diatom referred to as *Navicula pelliculosa* is incorrect. The true identity of *N. pelliculosa* has been established in various European publications.

The book is excellently produced with only some minor spelling and printing errors. The bibliography is bounteous with just on 1 000 items in total and numbering between 23 and 108 items per chapter. In some of the chapters there appears to be some bias in favour of English language references. The chapters are well illustrated with figures of high quality. Figure captions are usually adequate and accurate but occasionally fail to give the method of photography employed. A most useful 36-page subject index, which appears to be fairly comprehensive, completes the book.

This is a highly recommended reference work for both under- and post-graduate study and should be acquired by all biological reference libraries. Unfortunately, the high price may deter individuals and specialists interested in only a section of the field covered, from purchasing this book.

F. R. SCHOEMAN

PHYSIOLOGICAL PLANT ECOLOGY 1: RESPONSES TO THE PHYSICAL ENVIRONMENT, edited by O. L. Lange, P. S. Nobel, C. B. Osmond and H. Ziegler, with pp. xv + 625, 110 figures. Berlin, Heidelberg, New York: Springer-Verlag, 1981. Volume 12 in "Encyclopedia of Plant Physiology, New Series". DM 239, approx. US \$111.30. ISBN 3-540-10763-0.

It is high time that plant biologists sorted out the difference between physiological plant ecology and plant ecophysiology. The former emphasises ecology, the latter physiology. There is obviously an area of overlap but, at least in my view, physiology

is aimed at what goes on inside a plant and ecology deals with the levels of integration above that. Failure to distinguish between the two has detracted from the value of this first part of the four volume series, since, although there are a number of interesting and informative chapters, the book is in general neither one nor the other. It is noteworthy that although the book is titled *Physiological Plant Ecology*, the editors have titled their own introductory chapter "Perspectives in Ecological Plant Physiology". This review is written from the perspective of an ecologist.

This first part of the four-part series, *Responses to the Physical Environment*, consists of 17 chapters by 22 contributors (in addition to an Introduction by the editors), making up 625 pages of well-printed and easily readable type. It has been well produced with very few errors. There are seven chapters on radiation and responses to radiation in terrestrial plants, two on the aquatic environment (one of which is specifically on light). Five chapters deal with temperature, and there is one each on wind, fire and the soil environment.

The best chapters are those which deal in some depth with the physiological responses of plants to various aspects of the environment. It is a pity that the editors did not try to achieve a more consistent framework for the chapters.

The sections on Ecological Implications, at the ends of chapters 5 and 6, were useful contributions and would have enhanced the value of the other chapters.

Chapter 8, on the aquatic environment, is too superficial to be of much use, as are the final three chapters on wind, fire and the soil environment. Each of these four topics requires a book of their own to do them any justice. Chapter 11, on micro-organisms, is out of place.

In general, the first five chapters on light and chapters 10, 12, 13 and 14 on temperature are good contributions and make the book worth-while.

The bibliographies are up to date and most of them are comprehensive. There is both an author and subject index, and the latter is well constructed. The level of the book is suited mainly for final year undergraduate and postgraduate students. However, at US \$112 it is destined mainly for libraries, where it will be a useful reference.

B. H. WALKER

HORMONAL REGULATION OF DEVELOPMENT I, edited by J. Macmillan, with pp. vi + 681. Berlin, Heidelberg, New York: Springer-Verlag, 1980. Volume 9 in "Encyclopedia of Plant Physiology, New Series", edited by A. Pirson and M. H. Zimmerman. US \$134.60. ISBN 3-540-10161-6.

This is the first of a set of three volumes in the New Series of the *Encyclopedia of Plant Physiology* intended to cover the field of plant growth substance-controlled regulation of growth and development. The planning of the three volumes was the responsibility of N. P. Kefford of the University of Hawaii. In Volume I consideration is given to the molecular and subcellular components of hormonal regulation, and a refreshing approach has been adopted. Instead of treating each class of hormone separately, an attempt is made to examine the properties and principles common to all classes. Kefford argues that such an approach allows examination of the hypothesis that differing classes of hormones, "acting according to common principles, are determinants of processes and phases in plant development". This seems a logical approach since it is assumed that the major groups of plant hormones (and

other growth-affecting substances) act separately, sequentially or in concert on the basic processes of plant growth and development. In the Introduction, the editor, J. MacMillan of the University of Bristol, presents the scope of the volume and gives a chapter synopsis in a way that makes much additional review comment seem redundant.

There are six chapters. Chapter 1 gives a brief history of the five classes of hormones, lists the individual substances, and their occurrence, and includes other constituents which affect plant growth. Chapter 2 deals with extraction, purification, and identification techniques, and presents some case histories. No mention, however, is made of ethylene, not even under the heading Identification without isolation. In chapter 3 quantitative analytical aspects are dealt with. This is a provocative chapter seeking, as pointed out by the editor, to stimulate critical appraisal of the accuracy of methods used by investigators. Again, reference to ethylene is missing. Immunological assays are mentioned briefly, although their increased use and eventual supersession of the bioassay is foreseen. (Developments in 1980 and 1981 subsequently showed that radioimmunoassay of indoleacetic acid, abscisic acid and other hormones has become a reality.)

Chapter 4 is the heart of the book, not only in its length but in its very thorough, scholarly treatment of the biosynthesis and metabolism of all five hormone classes. Chapters 5 and 6 review receptor sites and molecular effects, respectively. Finally, the book contains nearly 100 pages of author and subject indexes.

This is the kind of reference work that sells itself, even though it has been very well written, edited and produced. It probably was a major task to limit its length (681 pages compared to 1357 of its counterpart 21 years earlier), but this obviously is a factor that has kept the costs down. The price of US \$134.60 (or \$107.70 for purchasers of Vols 9, 10 & 11) will ensure that this book finds its way also to the private bookshelf.

CHRIS H. BORNMAN

PLANT GROWTH SUBSTANCES 1979, edited by F. Skoog, with pp. vi + 527 and 209 figures, Berlin, Heidelberg, New York: Springer-Verlag, 1980. US \$57.90. ISBN 3-540-10182-9.

This volume represents the proceedings of the 10th International Conference on Plant Growth Substances held in Madison, Wisconsin in July 1979. As a proceeding's volume it is in a class of its own and one that editors of past and especially future conference proceedings would be wise to consult.

The publication has the appearance of a text book: there is uniformity of style and ample evidence that much thought and careful planning had gone into its preparation. The conference itself was organised into 11 sections, each with a chairman who was responsible for the arrangement of the topic material and the invited reports. These chairmen not only introduced the topics and led the discussions, but also assisted in the editing of the invited reports.

Each of the five classes of plant growth substances (auxins, cytokinins, gibberellins, abscisic acid and ethylene) is represented in a section. Four other closely related sections are devoted to new growth factors (this comprises a two-page summary), hormonal regulation in plant reproductive development, hormonal regulation of morphogenesis, and agricultural uses of plant growth regulators. The remaining two

sections include a historic review and a commemorative symposium. The former, under the title Origin and development of plant growth substance research, includes reviews respectively by J. Heslop-Harrison and K. V. Thimann on Darwin and the movement of plants and the development of plant hormone research since 1920. The latter section on plant movements was organised and presided over by A. W. Galston to commemorate the publication in 1880 of Darwin's *The Power of Movement in Plants*.

A total of 244 abstracts were submitted to the conference, but only 50 reports were accommodated in the proceedings, indicating that a strict selection procedure was applied. The papers reflect this. In the sections on the individual classes of hormones most of them report current states of knowledge, many dealing with metabolic aspects, and a number with mechanisms of action and physiological rôles in plants. In a departure from previous proceedings, the rapidly expanding practical utilisation of plant hormone research is acknowledged in separate sections on morphogenesis, reproduction and agricultural application. The section on agricultural uses of plant growth substances is one of the most interesting, for it is here that the expanding and galloping applications of gibberellin and ethylene, respectively, are considered. Within its manifold effects ethylene's influence spans all phases of plant development. As D. R. Dilley puts it: "Ethylene, indeed, is a busy gas."

As was the case with previous Plant Growth Substance Conference proceedings, that of the 10th meeting will be an essential aid to the plant hormone physiologist.

Incidentally, the 11th conference took place in Aberystwyth in July 1982.

CHRIS H. BORNMAN

THE DEFINITION OF LEAF CONSISTENCE CATEGORIES IN THE FYNBOS BIOME AND THEIR DISTRIBUTION ALONG AN ALTITUDINAL GRADIENT IN THE SOUTH EASTERN CAPE

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ABSTRACT

Leaf consistence is a morphological feature which is used as an attribute for the structural classification of communities and for the evolutionary interpretation of plant form and function. There are, however, no unambiguous criteria for the characterisation of leaf consistence categories. In this paper criteria for the subjective categorisation of leaf consistence by "feel" are tested by determining indexes of sclerophylly and succulence on leaves classed on a *a priori* basis as sclerophyll, orthophyll, fleshy (semi-succulent) or succulent. Results show differences in degree of sclerophylly (leaf dry weight per unit leaf area) and degree of succulence (maximal water content per unit leaf area) among the subjectively determined categories. The adaptive significance of the leaf consistence categories is indicated by direct gradient analysis of two parallel transects in the south eastern Cape, one in fynbos, the other in non-fynbos vegetation. In non-fynbos changes in leaf consistence along the gradient are interpreted largely as a response to changes in climate and soil moisture. We interpret the predominance of sclerophyll leaves throughout the fynbos gradient as a response to low soil fertility.

UITREKSEL

DEFINIERING VAN BLAARSTRUKTUUR-KATEGORIEË IN DIE FYNBOS BIOOM EN DIE VERSPREIDING DAARVAN LANGS 'N HOOGTE GRADIENT IN DIE SUIDOOS-KAAP

Blaarstruktuur as 'n morfologiese kenmerk word gebruik vir die klassifikasie van gemeenskappe en die evolusionêre interpretasie van plantvorm en funksie. Daar bestaan egter geen duidelike kriteria vir die subjektiewe indeling van blaarstruktuurkategorieë nie. In hierdie artikel word die subjektiewe indeling van blaarstruktuur deur die "voel" metode getoets deur indekse van sklerofilie en sukkulensie van blare op 'n *a priori* basis as sklerofil, orthofil, vlesig of sukkulensie aangegee. Resultate toon 'n verskil in die graad van sklerofilie (blaar droë gewig per eenheid blaar oppervlakte) en graad van sukkulensie (maksimale water inhoud per eenheid blaar oppervlakte) onder die subjektief bepaalde kategorieë. Die aanpasbaarheidsbetekenis van blaarstruktuur-kategorieë is aangedui deur 'n direkte gradient ontleding van twee parallel-

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Accepted for publication 12th November, 1982

le transekte in die Suidoos-Kaap, een in fynbos en die ander in nie-fynbos plante-groei. In nie-fynbos kan die veranderings interpreteer word as 'n reaksie op klimaats-en grondvog. Ons interpreteer die oorwegende sklerofille blaar-voorkoms in die fynbos gradient as 'n reaksie op die lae grondvrugbaarheid.

INTRODUCTION

Consistence is here defined to refer to both the firmness and thickness of a leaf (see Werger and Ellenbroek, 1978). This leaf characteristic has long been cited as a structural feature which correlates well with the regional climatic regime (e.g. Schimper, 1903). The adaptive significance of leaf consistence has been the focus of a number of studies (Loveless, 1962; Beadle, 1966; 1968; Small, 1972; 1973; Orians and Solbrig, 1977; Werger and Ellenbroek, 1978; Camerik and Werger, 1980; Bond, 1981), while leaf consistence *per se* is used as an attribute for structural classification with purely phytosociological objectives (Webb, Tracey, Williams and Lance, 1970; Bond, 1981). The definition of leaf consistence categories, however, and their recognition in the field, remains problematic (Loveless, 1962; Small, 1973; Beadle, 1966; Bond, 1981).

Leaf consistence grades from an orthophyll or soft-leaved type towards increasing sclerophyllly. All categories are subjective and cannot be sharply defined by any standards (Beadle, 1966). Students of vegetation in the Fynbos Biome (Kruger, 1978) have achieved some measure of agreement on a subjective classification of leaf consistence types based on "feel" (Bond, 1981: Table 1). Here we provide a test for the subjective criteria used in this scheme (see Table 1) by determining indexes of sclerophyllly and succulence (Camerik and Werger, 1980) on leaves, categorised on an *a priori* basis as orthophyll, sclerophyll, fleshy (semi-succulent) or succulent.

Direct gradient analysis (Whittaker, 1967) has proved to be an effective tool in highlighting the relations of plant community structure to environment (Mooney and Harrison, 1972; Mooney, Gulmon and Parsons, 1974; Parsons and Moldenke, 1975; Werger and Ellenbroek, 1978; Cowling and Campbell, 1980; Bond, 1981). We briefly indicate the adaptive significance of leaf consistence by examining the relative importance of consistence categories along parallel altitudinal gradients in fynbos and non-fynbos vegetation in the south eastern Cape.

MATERIAL AND METHODS

Consistence determination

Branches were sampled from a range of species subjectively classed into consistence categories (Table 4) by ourselves in the field. All samples were collected at 11h00 in mid-December from species growing in the National Botanic Gardens, Kirstenbosch. Soil type and microclimate were regarded

TABLE 1.

Subjective categorisation of leaf consistence by "feel" [adapted from Bond (1981)].

Texture	Characterisation and examples
Succulent	Leaves turgid, express copious liquid when squeezed between thumb and forefinger <i>Delosperma</i> , <i>Mesembryanthemum</i> , <i>Crassula</i> , <i>Euphorbia mauritanica</i>
Fleshy (Semi-succulent)	Leaves usually pulpy, little liquid expressed but leaves collapse with a rubbery or gelatinous texture when rolled between thumb and forefinger <i>Relbunium genistaefolia</i> , <i>Chrysocoma tenuifolia</i> , <i>Pteronia fasciata</i> , <i>Felicia filifolia</i>
Sclerophyll	Leaves hard, coriaceous and thick, breaking when folded <i>Protea</i> , <i>Phyllaea</i> , <i>Passerina</i> , <i>Sideroxylon inerme</i>
Orthophyll	Leaves soft, thin and pliant when folded <i>Ocotlea bullata</i> , <i>Clusia pulchella</i> , <i>Gnidia coriacea</i> , <i>Indigofera denudata</i>

as uniform for the whole sample. No visible signs of leaf chlorosis or flaccidity were noted.

Sampled branches were sealed in plastic bags and immediately transported to the laboratory. Ten leaves were selected from each species and submerged in a container of distilled water and kept in a dark coldroom (10 °C) for 24 h to achieve maximum hydration. The next day fresh mass and the surface area of each leaf were determined. Dry mass was determined by oven-drying the leaves at 105 °C for 24 h. With these data the following parameters could be calculated (Camerik and Werger, 1980):

Degree of sclerophylly, defined as the leaf dry mass per unit (bifacial) leaf area (g dm^{-2}).

Degree of succulence defined as the maximal water content of the leaf per unit (bifacial) leaf area (g dm^{-2})

We did not use Loveless' (1962) index of sclerophylly (per cent crude fibre plus per cent crude protein) as it would be of doubtful value in distinguishing between orthophyll and succulent leaves.

Direct gradient analysis

The vegetation transects were located in the Gamtoos river valley (S 33° 50', E 24° 55'), from near the village of Hankey on the valley floor to near

TABLE 2.
Vegetation data for stations on the Gamtoos gradient. (A = low altitude station, E = high altitude station)

Station	Vegetation type	Vegetation structure ¹	Dominant species
FYNBOS			
A	Coast Renosterveld, Dry Grassy Fynbos	Low Mid-dense Small-leaved Shrubland with a Mid-dense Grassy Understorey	<i>Elytropappus rhinocerotis</i> , <i>Themeda triandra</i> , <i>Erica decipiens</i> , <i>Merxmuellera stricta</i>
B	Grassy Fynbos	Low Mid-dense Ericoid Shrubland with a Mid-high Sparse Proteoid Shrub Overstorey and a Mid-dense Grassy-Restoid Understorey	<i>Protea neriifolia</i> , <i>Themeda triandra</i> , <i>Restio triticeus</i> , <i>Erica pectinifolia</i>
C	Dry Proteoid Mountain Fynbos	Low Mid-dense Heathland with a Mid-high Mid-dense Proteoid Shrub Overstorey and Mid-dense Restoid Understorey	<i>Leucadendron eucalyptifolium</i> , <i>Hypodiscus striatus</i> , <i>Protea neriifolia</i> , <i>Restio triticeus</i>
D	Dry Proteoid Mountain Fynbos, Proteoid Mountain Fynbos	Low Mid-dense Heathland with a Tall Open Proteoid Shrub Overstorey and a Mid-dense Restoid-Cyperoid Understorey	<i>Leucadendron eucalyptifolium</i> , <i>Protea eximia</i> , <i>Hypodiscus striatus</i> , <i>Tetraria compressa</i>
E	Proteoid Mountain Fynbos	Closed Restioidland with Tall Open Proteoid Shrub and Low Sparse Heath Overstoreys	<i>Leucadendron loerense</i> , <i>Erica copiosa</i> , <i>Hypodiscus synchroolepis</i> , <i>Thamnochortus argenteus</i>

Station	Vegetation type	Vegetation structure ¹	Dominant species
NON-FYNBOS			
A	Succulent Thicket	Mid-high Closed Large-leaved and Succulent Shrubland	<i>Portulacaria afra</i> , <i>Pappea capensis</i> , <i>Euclea undulata</i> , <i>Brachylaena ilicifolia</i>
B	Succulent Thicket	Tall Closed Large-leaved and Succulent Shrubland with an Open Herbaceous Understorey	<i>Euphorbia grandidens</i> , <i>Sideroxylon inerme</i> , <i>Euclea undulata</i> , <i>Aloe ferox</i>
C	Thicket	Tall Closed Large-leaved Shrubland with a Low Sparse Large-leaved Tree Overstorey	<i>Euclea undulata</i> , <i>E. schimperi</i> , <i>Pterocelastrus tricuspidatus</i> , <i>Sideroxylon inerme</i>
D	Afro-montane Forest	Low Forest with a Tall Open Tree Overstorey	<i>Rapanea melanophloeos</i> , <i>Podocarpus falcatus</i> , <i>Canthium inerme</i> , <i>Brachylaena glabra</i>
E	Afro-montane Forest	Tall Forest with a Low Mid-dense Tree Understorey	<i>Gonioma kamassi</i> , <i>Ocotea bullata</i> , <i>Olea capensis</i> ssp. <i>macrocarpa</i> , <i>Podocarpus latifolius</i>

¹ Structural characterisation according to Campbell, Cowling, Bond and Kruger (1981).

the summit of the Elandsberg mountains, some 500 m higher. It was possible to place transects from approximately sea-level to 500 m in fynbos and non-fynbos vegetation. Corresponding stations were located at approximately 100 m intervals on each transect and at each station four 100 m² samples were randomly placed on different aspects (N, S, E, W). All slopes were uniformly moderate (8–16°). In each sample a full floristic list was made and the projected canopy cover and selected structural features for all species were noted. Leaf consistence was determined subjectively. Some floristic and structural data for transect stations are shown in Table 2.

Climate diagrams from three stations along the gradient are shown in Figure 1. The extremes of the gradient represent two distinct climates. Hankey has the typical valley climate of coastal plain valley bottoms in the south eastern Cape. Temperatures are generally higher than adjacent coastal mountain and maritime areas. These areas also have greater absolute maxima (40°C) and lower minima (−1,1°C) and greater diurnal variation throughout the year (see Louw, 1976). Monthly relative humidities are also lower, particularly during the warmest part of the day (Louw, 1976). Valley areas receive considerably less precipitation than adjacent mountains largely because they miss a great deal of post-frontal orographic rain from S and SSW winds and frontal rain associated with W and SW winds. Rainfall is also highly variable from year to year and may fall in any month although long-term averages do indicate spring and autumn maxima (Fig. 1).

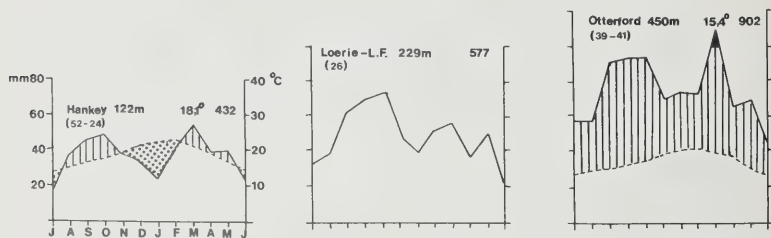


FIG. 1

Walter-Lieth climate diagrams (mean monthly air temperatures and rainfall) for stations on the Gamtoos transect. Temperature data adapted from climatically similar nearby station. (Uitenhage (108 m; 52 y) for Hankey, Van Stadens (452 m; 39 y) for Otterford). Hankey is representative of Stations A–B, Loerie Lower Forest of Station C, and Otterford of Station E. Data from S.A. Weather Bureau and Department of Forestry.

The coastal mountain climate (Otterford) is cooler, wetter and less variable on a daily and annual basis than the valley. Cool marine air keeps the temperatures equable although "berg wind" conditions may result in tem-

peratures of 39°C, and frost and snow are occasional in winter (Forestry Department, pers. comm.). Rainfall is high (900 mm) and falls in every month of the year with peaks in spring and autumn (Fig. 1).

The transects are interpreted as representing gradients of increasing rainfall and decreasing temperature and decreasing climatic variability. The reliability of available soil moisture is likely to improve with increasing altitude.

At each station a topsoil sample was collected from a north and south slope. Air dried soil samples were analysed for texture, pH and macronutrients by staff of the soil laboratory, Department of Agriculture and Fisheries, Winter Rainfall Region (Stellenbosch). Soil data are shown in Table 3.

RESULTS AND DISCUSSION

Consistence determinations

Results showing leaf characteristics of species are given in Table 4. It is important to restrict comparisons among consistence types to leaves of the same size category since both degree of sclerophylly and succulence show significant positive correlations with leaf size (Camerik and Werger, 1980). The degree of sclerophylly ranged from 0,02 to 1,50 gdm⁻² (Table 4). Camerik and Wergers' (1980) values for a tropical high mountain flora ranged from 0,29 to 1,19 gdm⁻² and they quote Müller Stoll (1947-48) as considering species with values of 0,7 gdm⁻² and higher as true xerophytes. Within our sample all species classed as sclerophyll exceeded this value, except for the leptophylls. Within the sclerophyll group, however, leaf size was positively correlated with the degree of sclerophylly ($r = 0,87$ $P < 0,01$). Orthophylls, and to a lesser degree fleshy leaves, had lower values while those for succulents were comparable to the sclerophylls.

Degree of succulence was highest for succulents and second highest for fleshy leaves. The values of typical succulents are in the range 5,1-14,9 gdm⁻² (Kluge and Ting, 1978) which encompasses the values of both species classed as succulents in Table 4.

Figure 2 indicates that degree of sclerophylly and degree of succulence can be used to distinguish leaf consistence categories and lends some credence to the subjective scheme.

Direct gradient analysis

The relative importance of leaf consistence along the gradient, in fynbos and non-fynbos vegetation, is shown in Figure 3. The succulent category includes stem succulents (where the stem is the major photosynthesising organ and therefore the physiological leaf) and herbaceous succulents. In both fyn-

TABLE 3.

Soil data for stations on the Gamtoos gradient. N refers to soil samples from north slope, S at south slope; all samples from top-soil (150 mm)

Station	Parent Material	Texture ¹	S-Value ² (Meq %)	Total N ³ (%)	Available P ⁴ (ppm)	pH ⁵
FYNBOS						
A	Enon conglomerate	N Sandy loam	7,1	0,215	8,0	4,6
B	Enon sandstone	N Sandy loam	1,5	0,058	2,0	4,2
C	Enon sandstone	S Loamy sand	2,3	0,061	2,0	4,8
D	Table Mountain Sandstone	S Sandy loam	3,5	0,098	3,0	4,7
E	Table Mountain Sandstone	N Sandy loam	4,9	0,084	2,0	4,8
		S Loamy sand	4,3	0,073	3,0	4,8
		N Loamy sand	3,7	0,069	3,0	4,0
		S Sandy loam	1,3	0,146	6,0	3,9
NON-FYNBOS						
A	Bokkeveld shale	N Loam	9,2	0,181	25,0	3,9
B	Enon mudstone	S Clay loam	16,5	0,292	10,0	5,2
C	Cango limestone, phyllite	N Sandy clay loam	7,8	0,157	9,0	4,5
D	Cango quartzite, phyllite	S Sandy clay loam	30,4	0,200	11,0	7,0
E	Table Mountain ⁶ Sandstone	N Loam	13,9	0,226	4,0	5,7
		S Loam	27,1	0,431	10,0	6,5
		N Sandy loam	8,8	0,389	25,0	4,5
		S Loam	4,4	0,201	11,0	3,7
		N Sandy loam	3,1	0,603	14,0	3,1
		S Loam	8,9	0,418	8,0	3,6

¹ Texture determined by the standard hydrometer method. Texture classes according to MacVicar *et al.* (1977).

² Sum of exchangeable Ca, Mg, Na and K. Cation determinations made on 0,5 m NH₄Cl extract by atomic absorption spectrophotometry.

³ Total nitrogen determined by the Kjeldahl method.

⁴ Available phosphorus on a Bray No. 2 extract.

⁵ pH measured in 1:2,5 N KCl (soil to solution ratio).

⁶ Colluvial deposits.

TABLE 4.
Leaf characteristics. Leaf consistence determined by "feel" (see Table 1); leaf size category according to Raunkier (1934). Results are the means of 10 separate leaves \pm standard deviations.

Leaf Texture	Species	Leaf size Category	Average Leaf size (cm ²)	Degree of Sclerophyll (g dm ⁻²)	Degree of Succulence (g dm ⁻²)
Orthophyll	<i>Pelargonium zonale</i>	mesophyll	42.9 \pm 8.7	0.44 \pm 0.05	1.87 \pm 0.22
	<i>Gardenia thunbergii</i>	microphyll	6.7 \pm 0.6	0.19 \pm 0.04	0.69 \pm 0.05
	<i>Polygala myrtilloides</i>	nanophyll	1.9 \pm 0.2	0.28 \pm 0.09	1.33 \pm 0.24
	<i>Asparagus scandens</i>	nanophyll	0.22 \pm 0.01	0.02 \pm 0.01	0.31 \pm 0.03
	<i>Anthospermum aethiopicum</i>	leptophyll	0.11 \pm 0.02	0.02 \pm 0.01	0.04 \pm 0.01
Sclerophyll	<i>Protea compacta</i>	mesophyll	22.2 \pm 1.4	1.50 \pm 0.06	0.91 \pm 0.06
	<i>Cassine peruvia</i>	microphyll	15.8 \pm 1.1	0.72 \pm 0.03	1.27 \pm 0.04
	<i>Carissa bispinosa</i>	microphyll	6.4 \pm 0.4	0.84 \pm 0.07	1.42 \pm 0.14
	<i>Olea europaea</i>	microphyll	4.7 \pm 0.7	0.75 \pm 0.05	1.08 \pm 0.05
	<i>Metastasia muricata</i>	leptophyll	0.18 \pm 0.04	0.35 \pm 0.02	0.70 \pm 0.07
	<i>Erica phylicaeifolia</i>	leptophyll	0.17 \pm 0.02	0.33 \pm 0.06	0.51 \pm 0.08
Fleshy (semi-succulent)	<i>Osteospermum ecklonis</i>	microphyll	5.1 \pm 0.5	0.31 \pm 0.04	2.36 \pm 0.13
	<i>Chrysanthemoides monolifera</i>	microphyll	4.8 \pm 0.6	0.63 \pm 0.01	2.01 \pm 0.27
	<i>Salvia africana</i>	nanophyll	1.4 \pm 0.1	0.36 \pm 0.03	2.53 \pm 0.18
	<i>Eriocapulus africanus</i>	leptophyll	0.18 \pm 0.02	0.30 \pm 0.06	1.85 \pm 0.17
Succulent	<i>Portulacaria afra</i>	nanophyll	1.2 \pm 0.1	0.89 \pm 0.02	7.52 \pm 1.93
	<i>Lampranthus multiradiatus</i>	nanophyll	0.48 \pm 0.02	0.54 \pm 0.03	12.07 \pm 2.12

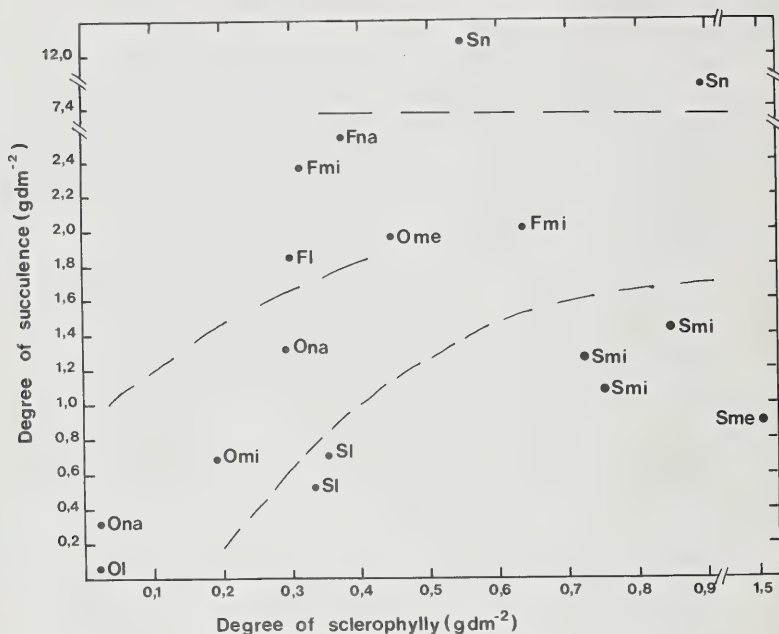


FIG. 2.

Scatter diagram showing relation of subjectively determined leaf consistence for 17 species to degree of sclerophylly and succulence. S = sclerophyll, O = orthophyll, F = fleshy, Sn = succulent, l = leptophyll, na = nanophyll, mi = microphyll, me = mesophyll.

bos and non-fynbos the contribution of deciduous species to total cover was negligible (0–5 % relative percentage cover).

Succulents and fleshy leaves

There is little doubt that the storage of water by plants represents an ecological adaptation; the plant is able to overcome periods of water deficiency with endogenous water reserves (Kluge and Ting, 1978). It would be desirable, though not possible in this study, to correlate succulence with the crassulacean acid metabolism (CAM) mode of carbon gain since the adaptive significance of CAM is well understood (Kluge and Ting, 1978). A high degree of succulence is, in itself, not a criterion for CAM; only those succulents which unify the sites of malic acid synthesis, storage and conversion within the same cells, can be expected to have CAM (Kluge and Ting,

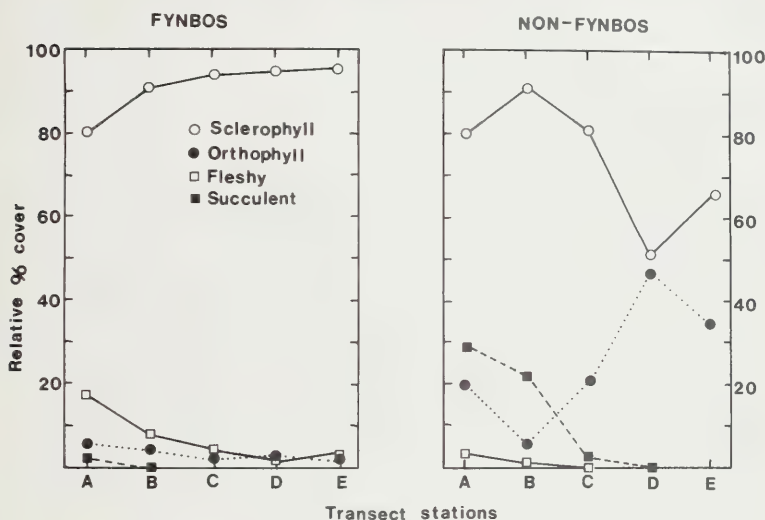


FIG. 3.

Importance of leaf consistence categories along an altitudinal gradient in fynbos and non-fynbos vegetation in the Gamtoos river valley. Succulents expressed as a percentage of total cover; other categories expressed as a percentage of total woody cover. Results are the mean values of four 100 m² samples at each station.

1978). In our study area most of the predominant succulent genera (*Euphorbia*, *Crassula*, *Portulacaria*, *Delosperma*, *Aloe*, *Senecio*) are known to possess CAM (Mooney, Troughton and Berry, 1977), while another (*Zygophyllum*) is non-CAM (Kluge and Ting, 1978).

CAM succulents are extremely economical in terms of the ratio of carbon gained to water lost but have associated costs of low rates of carbon fixation and are not competitive where soil moisture is not limiting for extended periods (Ting and Szareck, 1975; Kluge and Ting, 1978).

Predictably succulents had maximum cover in the low altitude valley climate areas (Fig. 3) with low unpredictable rainfall. Valley regions also experience great diurnal temperature fluctuations. It has been shown that optimum growth of some CAM species occurs under conditions of low night (10–15°C) and high day (25–30°C) temperatures (Neales, 1973; Osmond, Bender and Burris, 1976).

In fynbos fleshy leaves largely replace succulents at the xeric end of the gradient. They are common at corresponding non-fynbos sites with more

fertile soils (Table 3) (cf. Bond, 1981). As yet, the water relations and carbon gaining mechanism of fleshy plants have not been studied.

Sclerophyll and orthophyll leaves

There are two major hypotheses to explain the relative fitness of sclerophyll leaves to a particular habitat. The "drought" hypothesis, originally stated by Schimper (1903) is best articulated by Orians and Solbrig (1977). Sclerophyll has also been interpreted as a response to low levels of nutrients, particularly nitrogen and phosphorus (e.g. Loveless, 1962).

Orians and Solbrig (1977) have developed a descriptive cost-income model which takes into account water loss and carbon gain as well as morphological and physiological traits that affect these processes. Sclerophyllous leaves are interpreted as "high cost-slow profit" structures which are able to withstand high negative leaf water potentials through the development of energetically expensive supporting structures. These and other biochemical changes apparently restrict high photosynthetic rates when water is available (see Orians and Solbrig for supporting data) but allow the plant to yield profits when more mesophytic leaves have become an energetic liability. Sclerophyllous leaves are mostly longlived.

Orthophyll leaves ("low cost-quick profit") are cheaper to build and maintain per unit surface area and yield profits at faster rates than sclerophyllous leaves, provided soil water potential is low. As negative soil water potential builds up they cease to yield profits but maintenance costs continue, resulting in a net loss in keeping the leaf (Orians and Solbrig, 1977). It is clearly beneficial to drop leaves under these conditions.

This model predicts that sclerophyllous leaves are at a competitive advantage where periods of high soil moisture availability are short and erratic (e.g. semi-desert) or do not coincide with the growing season (e.g. mesic mediterranean climates (Miller, 1982; Mooney, 1982)). Orthophyll leaves will be favoured in tropical savanna, tropical rain forest and temperate broadleaf forest climates (Orians and Solbrig, 1977). We would expect, therefore, a predominance of sclerophyll at the xeric end of the Gamtoos gradients, with orthophylls becoming increasingly important towards the higher altitudes.

With some discrepancies this is the trend in the non-fynbos communities (Fig. 3). The trend observed for the fynbos communities does not agree with the predictions made by Orians and Solbrig's (1977) model. Here sclerophyll leaves predominate throughout the length of the gradient (Fig. 3). This cannot be explained by the soil moisture hypothesis alone; rather we interpret it as a response to the low fertility of fynbos soils (Table 3).

In recent years evidence has accumulated to support the hypothesis that

a sclerophyllous leaf is the expression of a metabolism found in plants that can tolerate low levels of certain nutrients, particularly phosphorus (Loveless, 1962; Beadle, 1966; 1968; Small, 1972; 1973; Steurbing and Alberdi, 1973). Loveless (1962) suggests that the excessive fibre contents typical of sclerophyllous leaves is due mainly to an absence of adequate phosphate. Thus products of metabolism which otherwise might have formed protein, are diverted along alternative metabolic pathways to form other end products, such as fibre. It is therefore possible to view sclerophyllous on infertile soils, particularly in areas where soil moisture is not limiting, as a non-adaptive feature determined by "biochemical" constraints (Gould and Lewontin, 1979) imposed on the leaf by a metabolism associated with limiting amounts of certain nutrients. On the other hand, adaptive advantages can be inferred, especially for both arid and infertile environments (Small, 1973). Small's (1973) hypothesis that there should be a degree of overlap in the ecological amplitude of plants adapted to arid and infertile environments is rejected for the Gamtoos transects since there are no species common to the xeric non-fynbos stations and the fynbos transect.

In conclusion it appears that patterns in the relative importance of leaf consistence in non-fynbos communities on relatively fertile soils, can be interpreted largely in terms of soil moisture and climatic factors; in fynbos communities low levels of soil nutrients may be of overriding importance in determining leaf consistence.

ACKNOWLEDGEMENTS

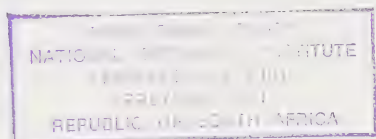
We thank Sue Painting and Wendy Lloyd for valuable laboratory assistance. R.M.C. collected the Gamtoos field data. This study was funded by the CSIR (R.M.C.), the Botanical Research Institute (B.M.C.) and is part of the Fynbos Biome Project. W. Bond, M. Werger and W. Westman made useful comments on an earlier draft.

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PROTEOID ROOTS IN THE SOUTH AFRICAN PROTEACEAE

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ABSTRACT

The 54 representative species of Proteaceae examined had abundant proteoid roots and it is concluded that they are normal components of the root systems of all 13 genera in southern Africa. Proteoid root terminology is revised and extended in view of the predominance of compound types in fynbos vegetation. Their relative contribution to the root system may reach up to 80 % total root dry weight but varies between individuals and species, and with plant age, season, soil type and location of parent roots in the soil profile. While proteoid-root formation is usually dependent on soil water availability, the presence is reported of "anomalous" young proteoid roots on *Leucospermum hypophyllocarpodendron* during summer drought. The number of rootlets may reach 650 per 10 mm length of parent root providing, together with their long root hairs, a substantial increase in surface area available for absorption of water and nutrients. There is, however, no simple relationship between abundance of proteoid roots and plant weight, at least in the first few years of growth.

UITTREKSEL

PROTEOÏDE WORTELS IN DIE SUID-AFRIKAANSE PROTEACEAE

Die 54 verteenwoordigende soorte Proteaceae ondersoek, het volop proteoïde wortels en word die gevolgtrekking gemaak dat dit normale komponente van al 13 genera in Suidelike Afrika is. Proteoïde terminologie is hersien en uitgebrei in die lig van die oorwegend saamgestelde tipes in fynbos-plantegroei. Hulle relatiewe bydrae tot die wortelsisteem mag soveel as 80 % droë gewig wees maar dit verskil tussen individue en soorte en met die ouderdom van plante, seisoen, en die posisie van die ouer-wortel in die grondprofiel. Alhoewel die proteoïde-wortelvorming afhang van die beskikbaarheid van grondwater, word die teenwoordigheid van "afwykende" jong proteoïde wortels by *Leucospermum hypophyllocarpodendron* gedurende somerdroogte vermeld. Die aantal worteltjies kan tot 650 per 10 mm lengte ouer-wortel oplewer wat met die lang wortelhare 'n betekenisvolle vermeerdering in oppervlakte beskikbaar vir absorpsie van water en voedingstamme is. Daar is egter geen eenvoudige verhouding tussen die voorkoms van proteoïde wortels en plantge-
wig nie, ten minste nie gedurende die eerste paar groeijare nie.

INTRODUCTION

Proteoid roots are dense clusters of rootlets in longitudinal rows (Fig. 1), and were first described for the family Proteaceae in Australia by Purnell (1960) and elaborated on by Lamont (1972a). Until recently, the South Afri-

Accepted for publication 11th November, 1982.



can literature on the Proteaceae was devoid of references to these structures (e.g. van Staden, 1968) though Vogts (1960) clearly alluded to them in her priority-for-research question "... why the superficial roots are so extremely sensitive and whether the presence of mycorrhizae is necessary to continued development." Proteoid roots are not mycorrhizal but are now considered analogous in their function (Lamont, 1982). More recently, Pathmaranee (1974) and Lamont (1981a), both in Australia, recorded some cultivated South African species with proteoid roots. In South Africa, Low (1980) has also made preliminary records from field excavations in the Cape, though proteoid roots were not observed on all plants, and van Staden *et al.* (1981) considered the rootlets of *Protea neriifolia* which formed in tissue culture were proteoid. The aim of this project was to examine representatives of the full range of South African Proteaceae for proteoid roots. By quantitative studies it was also hoped to obtain information on their relative morphology, contribution to the root system, occurrence in the field, factors controlling their formation and clues to their functional importance to the plant.

MATERIAL AND METHODS

Root systems were washed free of soil particles, separated into proteoid and non-proteoid root portions, and dried at 80°C for 48 h. For weighing purposes, even within compound proteoid roots, parent roots not bearing proteoid rootlets were considered non-proteoid. Morphological measurements were made with vernier calipers, often with the aid of a x10 dissecting microscope. Roots for electron microscopy were fixed in 70% alcohol, dehydrated in an alcohol-amyl acetate series, critical-point dried, gold-coated and scanned with a Jeol JB 35C electron microscope.

Nine-month plants referred to in the text were grown in two parts decomposed leaf litter: six parts siliceous gravel in plastic pots. They were drip-fed daily with tapwater and were 40% shaded in summer. Two-year cuttings were grown in two parts compost: one part loam: three parts sand in plastic bags. They were watered overhead with tapwater as required and kept in the open. Four-month seedlings of *Leucadendron laurum* under

FIG. 1.

Proteoid roots as viewed with scanning electron microscope. A, rootlets of mature proteoid root showing dense mat of root hairs up to their tips. B, rootlets of young proteoid root prior root hair development. C, proteoid rootlets just emerging in longitudinal rows from the parent root. D, surface view of mature proteoid root showing crowding of rootlets and their close association with soil particles (on the left). A-C = *Leucadendron salicifolium*, D = *L. laurum*. Scale: A = 1 mm, B-D = 100 μ m.

the previous treatment were transplanted into 2,5ℓ plastic pots containing either Clovelly sand from Pella via Atlantis or Hutton clay-loam from Jonkershoek. They were grown for a further 22 wk in a plastic greenhouse, watered with tapwater, and three random replicates of each were selected for root analysis.

RESULTS AND DISCUSSION

Taxonomic distribution

Table 1 shows that all specimens of all (54) species examined possessed proteoid roots (nomenclature follows the latest revision available). This included two *Aulax* species (three in genus), one *Brabejum* (one), three *Dia-stella* (five), two *Faurea* (five), ten *Leucadendron* (81), six *Leucospermum* (47), two *Mimetes* (16), one *Orothamnus* (one), two *Paranomus* (17), 12 *Protea* (83), eight *Serruria* (50), two *Sorocephalus* (11) and three *Spatalla* (20).

In association with what is already known about the proteoid-root bearing propensity of the sub-families Proteoideae (12 genera in South Africa) and Grevilleoideae (one genus in South Africa) (Lee, 1978; Lamont, 1981a), the results here suggest that proteoid roots are normal components of the root systems of all taxa in (southern) Africa. This is in contrast with Australia, where there are five genera lacking proteoid roots, especially in the primitive Persoonioideae. (The claim that *Agastachys* (Proteoideae) lacks proteoid roots (Lee, 1978) needs further investigation).

Expanded terminology

Following Purnell (1960), simple proteoid roots comprise a single cluster of rootlets (Fig. 2a). They are sometimes produced sequentially (in "series") along a parent root during the one growing season (Lamont, 1972a). Compound proteoid roots are defined here as a group of three or more clusters of rootlets borne on three or more parent roots (in "parallel"). The compound root therefore refers to a cluster of simple proteoid roots (Purnell, 1960: Fig. 2b). Clusters of rootlets are considered here to belong to separate compound proteoid roots if they are separated by more than one lateral root not bearing clusters of rootlets. Second order parent roots may arise from the axis of a primary proteoid root borne along the first order (original) parent root. This is defined here as a "closed" compound proteoid root. If the secondary proteoid roots arise from a non-proteoid portion of the parent root, the compound proteoid root is regarded as "open" (Fig. 2b). If only some of the second-order parent roots arise from a proteoid axis it is "incompletely-closed". If a primary proteoid root is present (usually terminal) but none of the second-order parent roots arise from it, the compound pro-

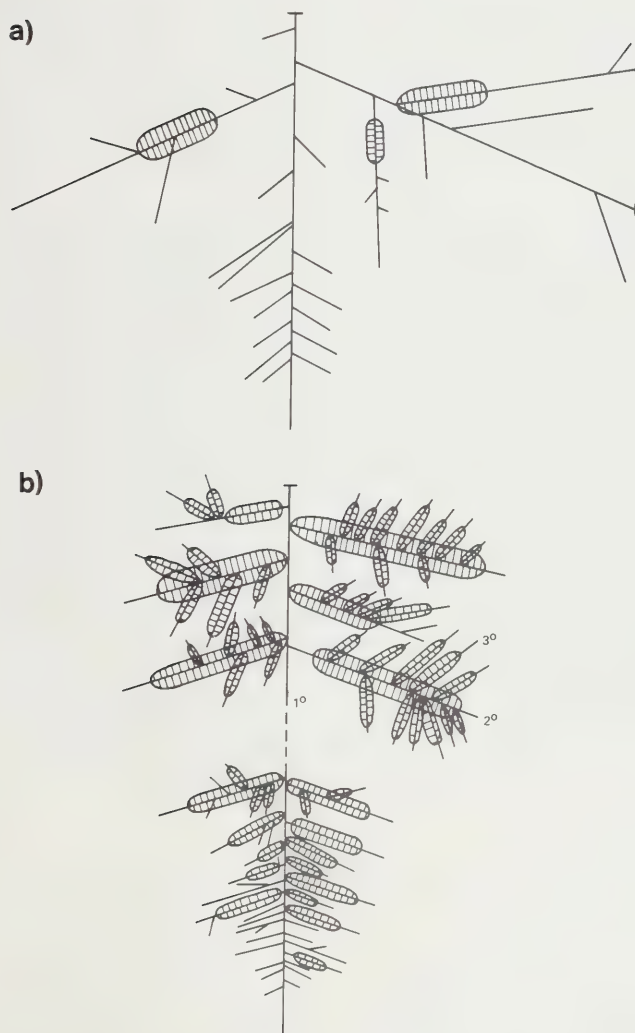


FIG. 2.

a. Part of a new season's lateral branch of *Serruria florida* with three simple proteoid roots. b. The same for *Leucospermum formosum* showing an "open" compound root with 28 second order (2°) parent roots and 111 simple proteoid root components (middle portion omitted). Note that all but two of the third order (3°) parent roots are "closed". Not drawn to scale.

teoid root is "incompletely-open". Tertiary and (the extremely rare) higher order proteoid roots are usually closed with respect to their parent roots, but otherwise the same terminology applies. For example, the compound proteoid roots of *Leucospermum formosum* are open or incompletely-open, with closed or incompletely-closed tertiary proteoid roots, and closed quaternary and quinternary proteoid roots (Fig. 2b).

Morphometrics

Returning to Table 1, all plants possessed at least some simple proteoid roots, with those of the genera containing the smallest plants, *Serruria*, *Sorocephalus* and *Spatalla*, remaining essentially simple throughout the life of the plant. Compound proteoid roots, usually open, were common in the other genera and contributed increasingly to the root system as plants increased in age (e.g. *Brabejum stellatifolium*, Table 1). Only *Leucospermum* and *Mimetes* were well represented by partly-closed, as well as open, compound proteoid-roots in mature plants, while most proteoid roots of *Orothamnus* were closed compound, though they were sparsely branched. The maximum number of second-order parent roots per compound proteoid root was 40 (*Leucospermum conocarpodendron*), with *Protea repens* having up to 35. Branching of compound proteoid roots was least in *Spatalla*, *Sorocephalus*, *Serruria* and *Faurea*. Individual proteoid roots tended to be smallest in *Spatalla*, *Paranomus* and *Faurea* (<35 mm long, <15 mm wide) and largest in *Leucadendron* and *Leucospermum* (<75 mm long, <35 mm wide). Older plants tended to have larger individual proteoid roots (e.g. *B. stellatifolium*, *Leucadendron laureolum*). The longest, simple proteoid root noted was 75 mm (*Leucospermum conocarpodendron*) and the shortest was 1.5 mm (*Spatalla racemosa* and *O. zeyheri*). The widest was 34 mm (*Leucospermum parile*) and the narrowest 1.4 mm (*Spatalla incurva*).

TABLE 1.

Occurrence and morphology of proteoid roots in 54 species of Proteaceae indigenous to southern Africa.

Species	Specimens	Description of proteoid roots			
		Type ⁺	No. of 2° rts*	Length (mm)	Width (mm)
<i>Aulax cancellata</i>	9 mth seedlings, sand-humus mix	S,O/C	—	5-30	—
<i>A. umbellata</i>	9 mth seedlings, sand-humus mix	SO	—	5-40	—
	Mature shrub, sandstone, Kogelberg	S,O,C	10	3-44	3-14

Species	Specimens	Description of proteoid roots			
		Type ⁺	No. of 2° rts*	Length (mm)	Width (mm)
<i>Brabejum stellatifolium</i>	2 yr seedlings, shale, Kirstenbosch	S,O	9	5-27	7-15
	7 m tree, shale, Kirstenbosch	O	20	6-43	6-20
<i>Diastella buekii</i>	2 yr cutting, sandy loam, Kirstenbosch	S,O, O/C,C	10	3,5-35	6,5-13
<i>D. proteoides</i>	Mature shrubs, fine sand, Pella	S,O,O/C	8	5-39	5-22
<i>D. serpyllifolia</i>	3,5 yr shrublet, rocky sandstone, Bot River	S,C,O/C	7	6,5-29	4-13,5
<i>Faurea macnaughtonii</i>	2 yr cutting, sand-humus mix	S	0	10-16	5-12,5
	1,4 m seedling, humic loam, Knysna forest	S,O/C	2	3-19	4-15
<i>F. speciosa</i>	5 yr shrub, sandy loam, Kirstenbosch	S,O	7	2-21	3,5-12
<i>Leucadendron argenteum</i>	3 m tree, sandy loam, Kirstenbosch	S,O	28	3-66	5-13
<i>L. discolor</i>	9 mth seedlings, sand-humus mix	S	0	5-20	—
<i>L. eucalyptifolium</i>	9 mth seedlings, sand-humus mix	S,O	—	5-30	—
<i>L. floridum</i>	6 yr shrub, laterite ^o	S,O	—	—	—
	2 yr cuttings, sand-humus mix	S,O	6	2,5-27	2,5-17
<i>L. galpinii</i>	3 yr shrub, coarse sand	S,O ^o	—	—	—
<i>L. laureolum</i>	10 mth potted seedlings, fine sand, Pella	S,O, C,O/C	12	3,5-40	2,3-18
	13 yr shrub, rocky sandstone, Bot River	S,O,O/C	24	3-60	4-20
<i>L. muirii</i>	3 yr shrub, coarse sand ^o	O	—	—	—
<i>L. salicifolium</i>	10 mth seedlings, sand-humus mix	S	0	—	—
<i>L. salignum</i>	2 yr seedlings, sandstone, Bainskloof	S	0	30	10
	5 yr regrowth, fine sand, Pella	S,O	—	—	—
<i>Leucospermum cordifolium</i>	2 yr seedlings, coarse sand ^o	S,O/C	—	—	—
	2 yr cuttings, sand-humus mix	O,C, O/C	7	6-31	4-13
<i>L. conocarpodendron</i>	2,0 m shrubs, stony sand, base Table Mt	S,O, C,O/C	40	2,5-75	3,5-15
<i>L. formosum</i>	2 yr cuttings, sand-humus mix	O,C, O/C	27	2,5-21	3-11
<i>L. hypophyllocarpodendron</i>	Mature rhizomes, fine sand, Pella	O,C, O/C	10	5-35	5-29

Species	Specimens	Description of proteoid roots			
		Type ⁺	No. of 2° rts*	Length (mm)	Width (mm)
<i>L. parile</i>	Mature shrubs, fine sand, Pella	S,O,O/C	20	29-54	10-34
<i>L. truncatulum</i>	2 yr seedlings, coarse sand ^o	S,O,C	—	10-30	6
<i>Mimetes cucullatus</i>	2 yr cuttings, sand-humus mix	S,O, C,O/C	8	4-22	3,5-15
<i>M. hirtus</i>	2 yr cuttings, sand-humus mix	S,O,C	9	4-31	4-17
<i>Orothamnus zeyheri</i>	2, 5 yr seedling, potted sand	S,O,C	5	1,5-31	6-13
<i>Paranomus reflexus</i>	600 mm cutting, loamy sand, Kirstenbosch	S,O,C	7	4-22	2-8
<i>P. spicatus</i>	2 yr cuttings, sand-humus mix	S,O,O/C	7	2-22	4-9
<i>Protea acaulos</i>	Mature rhizomes, fine sand, Pella	S,O,O/C	7	8-34	7-23
<i>P. nitida</i>	2 m tree, sandstone, Bainskloof	O	4	10-25	10-15
<i>P. aurea</i>	3 yr shrub, coarse sand ^o	O	—	—	—
<i>P. burchellii</i>	2 m shrub, fine sand, Pella	C	6	50	30
<i>P. cynaroides</i>	2 yr seedlings, sand-humus mix	S,O,C	9	2-6	4-13
<i>P. discolor</i>	3 yr seedlings, coarse sand ^o	S,O	—	—	—
<i>P. laurifolia</i>	2 yr seedlings, sandstone, Bainskloof	S	0	—	—
<i>P. magnifica</i>	3 yr seedlings, coarse sand	O	—	—	—
<i>P. neriifolia</i>	2,5 m shrub, fine sand, Kirstenbosch	S,O,C	17	2-36	3-17
<i>P. repens</i>	1 m shrub, fine sand, Pella	S,O,O/C	35	5-53	2-17
<i>P. speciosa</i>	18 mth seedlings, coarse sand ^o	O	—	—	—
<i>P. stokoei</i>	12 mth seedling, coarse sand ^o	S,O	—	—	—
<i>Serruria aitonii</i>	2 yr cuttings, sand-humus mix	S,O, C,O/C	13	4-30	3-19
<i>S. burmannii</i>	Flowering shrublet, fine sand, Pella	S	0	25	8
<i>S. ciliata</i>	2 yr cuttings, sand-humus mix	S,O	7	3-19	3-11
<i>S. elongata</i>	3 yr cuttings, sand-humus mix	S	0	3-15	2-10
<i>S. florida</i>	2 yr cuttings, sand-humus mix	S,C,O/C	6	7-32	4-13

Species	Specimens	Description of proteoid roots			
		Type ⁺	No. of 2° rts*	Length (mm)	Width (mm)
<i>S. pedunculata</i>	3 yr shrub, coarse sand ^o	S	0	—	—
<i>S. simplicifolia</i>	2 yr seedlings, fine sand, Pella	S	0	10–20	5
<i>S. vallis</i>	2 yr cuttings, sand-humus mix	S	0	3–29	6–16
<i>Sorocephalus lanatus</i>	2 yr cutting, brown sand, Kirstenbosch	S	0	4–17	2–5
<i>S. capitatus</i>	1,5 yr cuttings, sand-humus mix	S,O	4	3,5–36	3,5–17
<i>Spatalla incurva</i>	2 yr cutting, brown sand, Kirstenbosch	S,O	—	2–23	1,4–7
<i>S. parilis</i>	2 yr cutting, brown sand, Kirstenbosch	S,O	—	2–19	1,5–6
<i>S. racemosa</i>	5 yr shrublet, rocky sand-stone, Bot River	S,O	3	1,5–20	1,5–9

⁺ S = simple proteoid roots, O = open compound, C = closed compound, O/C = incompletely open or closed, letter in italics = most proteoid roots of this type

^o Cultivated plants in Perth, Western Australia

* Maximum number of second-order roots within a compound proteoid root bearing simple proteoid roots

Note: Length and width measurements refer to simple proteoid roots, even when these are components of compound proteoid roots.

Ontogenetically, and perhaps phylogenetically (Johnson and Briggs, 1975), the results suggest that compound proteoid roots are more "advanced" than simple types. Compound proteoid roots with many branches are more advanced than those with few branches. Closed are more advanced than incompletely-closed, which are more advanced than incompletely-open, which are more advanced than open. Similarly, compound proteoid roots with higher order clusters, are more advanced than those with lower order clusters.

All proteoid roots were made up of two (some *Paranomus reflexus* roots) to six (some *Leucadendron argenteum* roots) longitudinal rows of rootlets, as found for the genus *Hakea* in Australia (Lamont, 1972a). Proteoid rootlets varied in average width from 80 μ m (*Sorocephalus lanatus*) to 250 μ m (e.g. *Faurea speciosa*). These dimensions are much less than those for rootlets of *Protea neriifolia* developed in tissue culture (1,5–5 mm) and claimed to be proteoid (van Staden *et al.*, 1981). Their approximate length can be

determined by dividing width of proteoid roots in Table 1 by two. Most rootlets were in single rows (Fig. 1C), but those of *Mimetes cucullatus* and *M. hirtus* were in double rows due to compaction displacing alternate rootlets sideways (illustrated in Lamont, 1972a and to some extent in Fig. 1B). *Leucospermum hypophyllocarpodendron* was unusual in possessing some proteoid roots with non-contiguous "incomplete" rootlets (Table 5). The number of rootlets per unit axis length varied from 60 (*L. argenteum*) to 140 (*S. lanatus*) per 10 mm row, depending on diameter and arrangement of the rootlets (Table 5). Including all rows, this gives about 200 rootlets/10 mm axis length for ten-month seedlings of *Leucadendron laureolum* to 650 rootlets/10 mm axis length for typical proteoid roots of rooted cuttings of *M. cucullatus*. The root hairs on proteoid rootlets were often much longer than those on non-proteoid roots (compare Fig. 1C and D), ranging from 250 μm (*Serruria aitonii*) to 725 μm (*L. hypophyllocarpodendron*).

In an experiment with *Leucadendron laureolum* (Lamont, unpubl.), mature proteoid roots had 2.6 times the surface area per unit dry weight as adjacent non-proteoid roots, omitting any contribution by root hairs. The root hairs on proteoid rootlets were three times the length of those on non-proteoid roots (though of similar width and density). This gave an additional 5.84 mm² of surface per 1 mm² of epidermal surface, 2.6 times that of equivalent non-proteoid roots. The total root surface of mature proteoid roots per unit weight was consequently 5.4 times that of mature non-proteoid roots. This is consistent with Jeffrey's (1967) claim of 4.5 times for *Banksia ornata*, though the dense cover of root hairs on the proteoid roots of other species (e.g. *Brabejum stellatifolium*, *Faurea macnaughtonii*, *Protea cynaroides*) would greatly increase this figure.

Contribution to the root system

Nine months after germination, pot-grown *B. stellatifolium* had no proteoid roots, while they were abundant in *Aulax cancellata*, *A. umbellata*, *Leucadendron eucalyptifolium* and *L. laureolum* (Table 2). The delay in proteoid root initiation in *B. stellatifolium* was no doubt due to the large store of nutrients in the still-intact drupe. The smaller cotyledons on the other species, except *Aulax umbellata*, had already decayed. That commencement of proteoid root initiation is not necessarily tied to cotyledon abscission however (Lamont, 1972a) is confirmed by *A. umbellata* (and *Protea cynaroides*, Table 4), which had the greatest concentration of proteoid roots. As indicated by *Leucadendron*, there was as much variation in concentration of proteoid roots in the root systems between species in a given genus as there was between genera (see also Table 4). At this early stage in growth, there was also much variation in proteoid root production between

TABLE 2.

Production of proteoid roots by six pot-grown species of Proteaceae in relation to shoot and total root growth, nine months after germination. Results are mean \pm standard deviation for six plants, except *Leucadendron discolor* (twelve plants). Significant curvilinear correlations between number of proteoid roots and plant weight are indicated.

Species	Shoot wt (g) (A)	Root wt (g)	No. proteoid rts/plant (B)	No. proteoid rts/g root wt	Correl. A v B
<i>Aulax cancellata</i>	0.79 \pm 0.15	0.34 \pm 0.10	22 \pm 20	65 \pm 71	NS
<i>A. umbellata</i>	1.05 \pm 0.32	0.47 \pm 0.15	72 \pm 78	134 \pm 122	*(linear)
<i>Brabejum stellaifolium</i>	1.81 \pm 0.66	1.59 \pm 0.86	0 \pm 0*	0 \pm 0	NS
<i>Leucadendron discolor</i>	1.02 \pm 0.24	0.44 \pm 0.14	4 \pm 6	8 \pm 10	NS
<i>L. eucalyptifolium</i>	2.26 \pm 0.37	1.20 \pm 0.22	94 \pm 56	74 \pm 34	*(log)
<i>L. laurcolum</i>	3.08 \pm 0.64	1.05 \pm 0.39	50 \pm 26	47 \pm 17	NS

* One plant with one proteoid root; NS not significant; * significant at 5 % level.

TABLE 3.

Growth of *Leucadendron discolor* nine months after germination in relation to six plants with proteoid roots and six without. Results of tests of significance are given.

	No. proteoid roots	Total plant wt	Shoot wt	Root wt
Sig. Test	0 \pm 0	1.41 \pm 0.29	1.08 \pm 0.27	0.44 \pm 0.12
	8 \pm 4	1.52 \pm 0.36	0.97 \pm 0.20	0.45 \pm 0.10
	Mann-Whitney ***	NS Anovar	NS Anovar	NS Anovar

TABLE 4.

Contribution by new season's proteoid roots to the root systems of two-year-old pot-grown plants of eight species in six genera. Results are mean \pm standard deviation for three replicates.

	Shoot wt (g) (A)	Root wt (g) (B)	Ratio A/B	No. proteoid rts/g total wt	% proteoid rt wt/ total rt wt	Wt per proteoid rt (μ g)
<i>Leucadendron floridum</i>	3,35 \pm 0,87	0,70 \pm 0,44	4,8	176 \pm 33	20,2 \pm 7,1	1,1 \pm 0,3
<i>Leucospermum formosum</i>	7,08 \pm 1,13	1,43 \pm 0,44	5,0	249 \pm 153	12,7 \pm 6,6	0,6 \pm 0,1
<i>L. oleifolium</i>	6,57 \pm 0,61	1,06 \pm 0,34	6,2	18 \pm 11	2,6 \pm 2,2	1,3 \pm 0,4
<i>Minetes hirtus</i>	3,40 \pm 1,13	1,02 \pm 0,39	3,3	122 \pm 30	26,3 \pm 9,6	2,1 \pm 0,3
<i>Paranomus spicatus</i>	2,90 \pm 0,10	1,03 \pm 0,08	2,8	121 \pm 42	14,6 \pm 1,8	1,3 \pm 0,3
<i>Protea cynaroides</i> ⁺	1,27 \pm 0,40	0,40 \pm 0,06	3,2	272 \pm 74	29,7 \pm 2,7	1,1 \pm 0,3
<i>Serruria aitonii</i>	7,28 \pm 0,84	1,87 \pm 0,54	3,9	92 \pm 20	17,0 \pm 6,5	1,8 \pm 0,3
<i>S. vellaris</i>	2,01 \pm 0,61	0,43 \pm 0,12	4,7	39 \pm 6	10,0 \pm 1,3	2,7 \pm 0,3

⁺ Ten month seedlings with cotyledons still present; other species grown from cuttings.

replicates, as suggested by the high standard deviations. Proteoid root concentration in the rooted cuttings from mature plants (Table 4) was much more stable. The greater the number of proteoid roots in the root system of replicates, the higher the proportion of compound ones, suggesting physiological advancement of these plants (see earlier comments on Table 1).

Correlations (linear, logarithmic, exponential, power) between dry shoot weight and number of proteoid roots per seedling, were only significant for two of the six species. In functional terms, then, increased occurrence of proteoid roots cannot be held responsible for instances of greater plant growth in four of the six species. The two positive correlations can even be interpreted as the reverse—larger plants, under otherwise identical conditions, are more likely to have proteoid roots (Lamont, 1981a).

Advantage was taken of the absence of proteoid roots in six plants of *Leucadendron discolor* to compare their growth against six plants with them (Table 3). Again, those with proteoid roots were not larger than those without them. This is no doubt due, at this young stage, to lack of dependence on external supply of nutrients and too recent formation of proteoid roots. Variations in seed size, date of germination and soil attributes (nutrients, air and water availability, stimulatory bacteria, see Lamont, 1981a) between replicates could explain the apparent random fluctuations in occurrence of proteoid roots between plants.

Of seven species of rooted cuttings, only *Serruria aitonii*, *S. vallis* and *Leucospermum oleifolium* had <100 new season's proteoid roots/g total root weight (Table 4). The root systems of cuttings can be regarded as equivalent to new season's growth of mature plants, since these also are invariably of adventitious origin (Lamont, 1972a). *L. oleifolium* was the only species of the seven in flower (mid-March), had the fewest proteoid roots and yet the highest shoot/root ratio. Reproductive growth may well compete with root growth in this species and phenological studies might be informative. *L. formosum* on the other hand had greatest concentration of proteoid roots, up to 440/g total dry root weight in one replicate. This compares favourably with the other highest records of proteoid root abundance: 354 for one *P. cynaroides* seedling (Table 4), 557 for portion of the root system of an 18-month *Leucadendron laurum* in humus-rich soil (Lamont, unpubl.) and 578 for a surface lateral of a 3 m high *L. argenteum* at Kirstenbosch.

Proteoid roots were not weighed individually, but ranged from an average weight of 0.5 mg (*Leucospermum formosum*, mostly immature) to 3.0 mg (*Serruria vallis*) throughout the root system (Table 4). For comparison, proteoid roots in *Leucadendron laurum* seedlings of similar age weighed on average 7.3 mg in Clovelly sand (Table 7). There was some tendency for species with a greater number of proteoid roots to have smaller

ones on average (Table 4). This was apparently due to an increased proportion of compound proteoid roots with higher order (i.e. smaller) laterals bearing most of the (consequently smaller) simple proteoid root components (see Fig. 2b and Table 1).

The contribution of living proteoid roots by weight to the total root system varied from 1 % (*L. oleifolium*) to 37 % (*Mimetes hirtus*) (Table 4). Proteoid roots (including dead) accounted for 80 % of the dry weight of the surface lateral of the specimen of *L. argenteum* noted above. If proteoid roots increase the efficiency of nutrient uptake (Jeffrey, 1967; Malaczuk and Bowen, 1974; Lamont, 1982) then a positive correlation between % weight of proteoid roots in the root system and shoot/root ratio might be expected. That is, as the % contribution of proteoid roots increases, proportionately more shoot weight should be supported. No such simple, mechanical relationship is evident between replicates or species in Table 4. The reason is that growth is as much dependent on initial plant nutrient status and species recycling ability (Grundon, 1972) as on root morphology.

Factors affecting formation

Age. After nine months, all pot-grown seedlings of *Aulax umbellata*, *Leucadendron eucalyptifolium* and *L. laureolum* had proteoid roots in abundance (Table 2), but only half of *L. discolor* and no *B. stellatifolium* had them. Study of the two *Leucadendron* species over time (Fig. 3) shows absence of proteoid roots up to 17 weeks. By about 25 weeks all seedlings possessed them. *L. laureolum* shows a power function increase in number of proteoid roots with increase in shoot growth (r sig. at 1 % level). As discussed earlier, it is not possible to unravel cause and effect from such data. It is clear, however, that the older the plant the more likely it is to have proteoid roots, and that by the second year of growth they are standard components of the root systems of these species (also see Table 1).

Soil type. Nine-month seedlings of *Leucadendron laureolum* grown in Clovelly-type soil (fine sand) had almost 50 % more, and larger, proteoid roots than those in Hutton-type soil (clay-loam) (Fig. 4). This was partly attributable to the fact that root weight in Clovelly soil was twice that in the Hutton, despite the fact that the Clovelly soil had only one-third the level of extractable phosphate as the Hutton (C. Brown, unpubl.). It is possible that phosphate was at inhibitory levels in the Hutton, although in other species proteoid root production ceases altogether at levels which inhibit "normal" root growth (Lamont, 1972b). In view of the high water content of the potted Hutton soil (Lamont, unpubl.), the results are more consistent with the effects of mild waterlogging on root growth as demonstrated for other proteaceous species (Lamont, 1976).

TABLE 5.

Distribution of recently-emerged proteoid rootlets along the parent axis. Double rows result when alternate rootlets are displaced laterally as they emerge. Contiguous rootlets lack gaps between them within the longitudinal row. Incomplete rows have gaps exceeding diameter of rootlets within the axis.

Specimen	Rootlet arrangement	No. rtlets/row /10 mm axis
<i>Diastella proteoides</i>	Single row, contiguous, complete	75
<i>Leucadendron argenteum</i>	Single row, contiguous, complete	60
<i>L. floridum</i>	Single row, contiguous, complete	90
<i>L. salicifolium</i>	Single row, contiguous, complete	100
<i>Leucospermum formosum</i>	Single row, contiguous, incomplete ⁺	80
<i>L. hypophyllocarpodendron</i>	Single row, non-contiguous ⁺ , incomplete ⁺	75
<i>Mimetus cucullatus</i>	Double row, contiguous, complete	130
<i>M. hirtus</i>	Double row, contiguous, complete	75
<i>Serruria aitonii</i>	Single row, contiguous, complete	140
<i>Sorocephalus lanatus</i>	Single row, contiguous, complete	140
<i>Spatalla parilis</i>	Single row, contiguous, complete	100

⁺ This condition not common

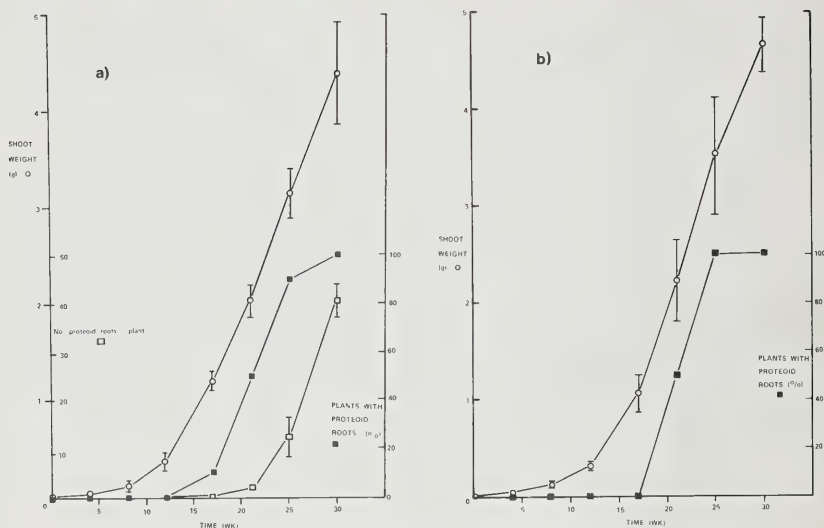


FIG. 3.

Presence of proteoid roots in relation to age of seedlings of *Leucadendron laureolum* (a, ten plants at each harvest) and *L. eucalyptifolium* (b, seven plants). Mean \pm standard errors are given. O—shoot dry wt, ■—% plants with proteoid roots, □—no. proteoid roots per plant.

Soil profile distribution. Examination of many plants in a range of soil types (Table 1) repeatedly confirmed that the proteoid roots were concentrated in the uppermost 100 mm of soil, especially in the decomposing litter and humus layers beneath the canopy of the plant, as found in Australia (Lamont, 1973). The abundance of compound proteoid roots in larger and older plants (Table 1) resulted in a distinct mat of proteoid roots just under the raw litter (e.g. *Leucadendron salignum* and *Protea burchellii* at Pella) though this only remained continuous under the plant canopy, unlike *Banksia* in Australia which may extend between plants (Jeffrey, 1967). The results for adult plants of *Leucospermum parile* at Pella will be described elsewhere (S. Jongens-Roberts and D. T. Mitchell, unpubl.), but preliminary data for two-year-old plants (Table 6) show that the pattern is established early. In this case, there was no decomposing litter layer and 90 % of all proteoid roots were concentrated in the uppermost 50 mm of soil. Both proteoid root number and weight fell away exponentially with depth, with

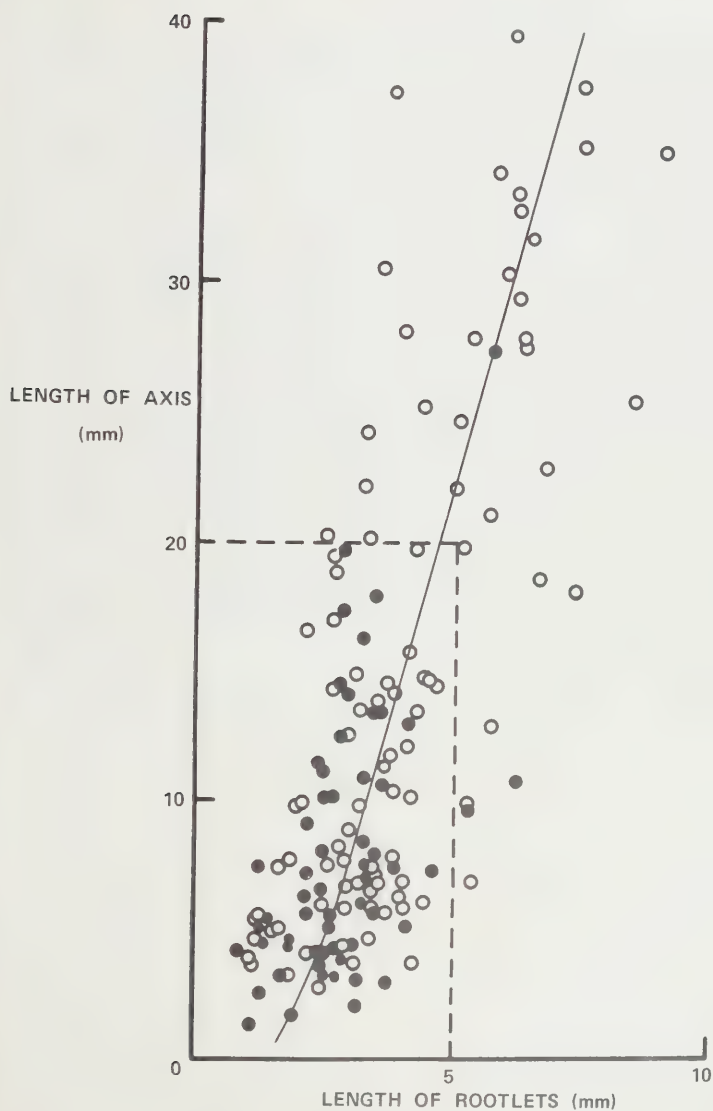


FIG. 4

Dimensions of proteoid roots of *L. lauroolum* in one plant grown in Clovelly sand (○) and one in Hutton clay-loam (●) for nine months. Note the essentially linear relationship between axes and rootlet lengths, and the paucity of large proteoid roots in the Hutton soil. Part of the wide variation about the best-fit line is due to inclusion of immature proteoid roots.

none below 150 mm. This pattern was in no way related to the distribution of lateral roots which remained fairly constant down to 600 mm, nor to soil water availability which increased below 300 mm (Table 6). There was a linear, rather than exponential, drop in soil organic matter with depth but, together with the nutrients released from the fire that initiated germination, the proliferation of proteoid roots at the surface can be related to enhanced nutrient availability here (Lamont, 1973).

Seasonality. The root systems of thirteen species examined in the field (Kirstenbosch, Bainskloof, Kogelberg Mts and Pella, see Table 1) during March 1980 usually only possessed dead proteoid roots. The rootlets were brown, broken off or lacked cortices or root hairs. The exceptions were plants of *Leucospermum hypophyllocarpodendron* examined in Clovelly sand at Pella on 3rd and 18th March, 1980. Some of the adventitious roots arising from the rhizomes possessed young and mature compound proteoid roots. The rootlets were white and densely-covered with root hairs (Tables 1, 5). The rhizosphere soil had a water content of 3,34 % (above field capacity of 2,4 %), while the surrounding soil had a water content of 0,34 % (below permanent wilting point of 1,8 %). One explanation is that dew rolled down the vertically-oriented leaves, over the rhizome and down the parent root to create a locally-moist environment for root growth. In view of the small surface area of these leaves, the hydrophobicity of this soil when dry, and the unreliability of such a source for ongoing root growth, this possibility seems remote. Active roots are quite capable of releasing water on the other hand (e.g. Lamont, 1981b), and a more likely explanation is that water was provided from the sub-soil via the massive taproot and released into the rhizosphere. By maintaining a moist rhizosphere these "anomalous" summer proteoid roots may serve to prolong nutrient release from the organic particles and take advantage of "out-of-season" showers (Lamont, 1982).

Following the first substantial autumn rains at Pella both "normal" and proteoid root growth commenced in *Leucospermum parile* at least (Table 7). By mid-June there was vigorous proteoid root growth at the same site by *Diastella proteoides* (flowering), *Leucadendron salignum*, *Protea repens* and *P. burchellii* and to a lesser extent *Serruria simplicifolia*. October appeared to be the critical month for cessation of proteoid root growth (Table 7). By mid-October, the surface soil around fifth-year plants of *Protea repens* and *P. burchellii* was dry and all roots were moribund. Under 20-year stands of these species however, with a thick layer of litter and canopies to the ground, the soil was still moist and young and mature proteoid roots were abundant. By late October proteoid root growth here had also ceased. However, excavations around *P. neriifolia*, *Leucadendron argenteum* and *Leucospermum conocarpodendron* at Kirstenbosch over summer showed growth

TABLE 6.
Distribution of roots through the soil (Clovelly-type) profile of two-year-old plants of *Leucospermum parile* at Pella (via Atlantis) on 2 June 1980

Soil* Depth (mm)	No. of proteoid roots	Wt of proteoid roots	Wt of lateralis	Wt of tap root	Soil water content (%)	Organic matter (%)
0-50	90	0.31	0.17	0.87	2.08	1.96
50-100	8	0.03	0.07	0.30	1.91	1.65
100-150	1	0.02	0.08	0.31	1.64 ^o	1.43
150-300	0	0.00	0.10	0.37	1.62 ^o	1.13
300-450	0	0.00	0.12	0.16	2.42	0.86
450-600	0	0.00	0.13	0.04	2.78	0.74

* soil core 250 mm diameter centred on base of plant.

^o below water content at 15 bar suction.

TABLE 7.
Seasonality of proteoid root growth related in general terms to that of other organs for four-year plants of *Leucospermum parile* at Pella (via Atlantis)

Date (1980)	Shoot growth	Reproductive growth	Root growth	
			Non-proteoid	Proteoid
3 March	+	-	-	-
1 April	+	-	-	-
13 May	+	-	+	+
2 July	-	+	+	+
21 October	-	+	+	+
31 October	+	+	-	*
12 December	++	-	-	-

- = no growth, + = moderate growth, ++ = maximum growth

* a few moist clusters present.

of both types of roots continued provided the soil remained moist (e.g. 5.9 % water content recorded beneath *L. conocarpodendron*). Examination of *Leucadendron laureolum*, *Diastella serpyllifolia* and *Spatalla racemosa* at Bot River on December 10 showed all surface roots to be dormant. Clearly, where surface water availability is highly seasonal so also is root growth, including production of proteoid roots, as previously demonstrated in a related mediterranean ecosystem (Lamont, 1976).

ACKNOWLEDGEMENTS

Bill Storm van's Gravesande propagated many of the plants especially for this project (Tables 1–3, Fig. 3). Kirstenbosch Botanic Gardens provided additional plants (Tables 1, 4) and John Winter and John Rourke are thanked for their support. Gary Brown helped me analyse the root systems of his *L. laureolum* plants, Gert Brits (Tygerhoek Experimental Farm) allowed me to inspect the roots of his *Orothamnus* plants and William Bond and Hans van Daalen (Saasveld Forestry Research Station) took me to *Fauarea macnoughtonii*. Ruth, Walter and Robert Middelmann provided generous hospitality at Bot River. Eugene Moll, Margie Jarmen, Derek Mitchell and all other members of the Fynbos Biome Project at the Botany Department, University of Cape Town are thanked for their support. Liz van der Pennen provided technical expertise on the SEM at WAIT. Research funds were provided by the CSIR and University of Cape Town (1980, with E. Moll). The project was undertaken during study leave granted by WAIT.

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POLLINATION OF *MIMETES HIRTUS* (PROTEACEAE) BY CAPE SUGARBIRDS AND ORANGE-BREASTED SUNBIRDS

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ABSTRACT

Promerops cafer (Cape Sugarbird) is a major pollen vector for *Mimetes hirtus*, brushing its head and throat against pollen presenters and stigmata as it forages for nectar. *P. cafer* is attracted to partially-opened inflorescences, in particular, by virtue of the large nectar standing crops present. Maximum pollen availability and viability coincide with most visits by *P. cafer*, and result in a relatively high degree of seed set. *Nectarinia violacea* (Orange-breasted Sunbird) visits *M. hirtus* occasionally, but does not transfer significant pollen loads.

UITTREKSEL

BESTUIWING VAN *MIMETES HIRTUS* (PROTEACEAE) DEUR KAAPSE-SUIKERBEKKIES EN JANGROENTJIES

Promerops cafer (Kaapse-suikerbekkie), is 'n belangrike stuifmeeldraer vir *Mimetes hirtus* omdat dit met kop en keel teen die stuifmeelhokke en -stempels skuur wanneer dit nektar soek. *P. cafer* word deur die gedeeltelike oop bloeiwyses gelok, veral as gevolg van die groot hoeveelhede nektar beskikbaar. Maksimum stuifmeel-beskikbaarheid en kiemkrag val saam met meeste besoeke deur *P. cafer*, en lei tot 'n betreklike hoë graad van saadvorming. *Nectarinia violacea* (Jangroentjie) besoek *M. hirtus* af en toe maar dra nie veel stuifmeel oor nie.

INTRODUCTION

Proteaceae constitute one of the major components of fynbos vegetation in the south-western Cape region of South Africa (Taylor, 1978). *Protea* is the only genus within this group whose pollination biology has been studied intensively (Rourke and Wiens, 1977; Wiens, Rourke, Casper, Rickart, La Pine and Peterson, 1982). Rodents are the pollinators for many dwarf species, although birds such as the Cape Sugarbird (*Promerops cafer*) and a variety of sunbirds appear to be the major pollen vectors in tall, shrubby

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species (Broekhuysen, 1959; Skead, 1967; Mostert, Siegfried and Louw, 1980).

Another genus of the Proteaceae that is endemic to the southern and south-western Cape, is *Mimetes*. This comprises twelve species, and occurs sporadically from Clanwilliam through the Cape Peninsula and Hottentots Holland Mountains, to Formosa Peak in the east (Rourke, 1982). One of the most geographically restricted species in this group is *Mimetes hirtus*, occurring in isolated populations on the Cape Peninsula, and on the south coast near Betty's Bay, Hangklip and Hermanus (Rourke, 1982).

Apart from the general observation that *M. hirtus* inflorescences are visited frequently by *P. cafer* and sunbirds, virtually nothing is known of the pollination biology of this species (Vogel, 1954). The main objectives of the present paper, therefore, are to establish whether *P. cafer* and/or sunbirds are significant vectors for *M. hirtus* pollen and whether the selection of inflorescences visited is related to the availability of nectar and viable pollen.

MATERIAL AND METHODS

Study areas

Field investigations were conducted at Betty's Bay, 90 km east of Cape Town on the south coast, and at Kirstenbosch National Botanic Gardens in Cape Town, during July and August, 1982. Topography, soil structure and general vegetation for both of these areas have been described previously (Fagan, 1973; Boucher, 1978).

The study area at Betty's Bay comprised several stands of *Mimetes hirtus* (Proteaceae) and *Erica perspicua* (Ericaceae), in which *Promerops cafer* and Orange-breasted Sunbirds (*Nectarinia violacea*) were the dominant nectarivores. Male and female *P. cafer* actively defended non-breeding territories in *M. hirtus* against conspecific birds and *N. violacea*. *N. violacea* was more frequently seen amongst *E. perspicua* than *M. hirtus*. The area in which plant and bird observations were made was located on a narrow belt of coastal seepage fynbos at the southern foot of Elephant Rock Mountain (Boucher, 1978).

Studies at Kirstenbosch were conducted using a group of 13 *M. hirtus* that had been grown from cuttings planted in poorly-drained soil on the lower south-eastern slopes of Table Mountain. No nectarivores were seen visiting inflorescences during the study period, possibly because of the small *M. hirtus* population, and the availability of numerous alternative nectar sources. Nevertheless, this site proved ideal for extended studies of flowering phenology and diurnal variation in nectar availability.

The Plant

M. hirtus is a relatively dense shrub, approximately 1.5 m in height, that bears numerous terminal flowering heads. Individual heads comprise several red and yellow inflorescences (capitula), each of which consists of 8–11 florets surrounded by involucre bracts. As each floret develops, a bent red style emerges from between the bracts, ultimately becoming fully erect when the pollen presenter dehisces from the anthers (Figure 1). Four tiny nectaries (hypogynous scales) are located at the base of each inflorescence, approximately 57 mm from the distal ends of the fully extended styles (Rourke, 1982; Collins, unpublished data).

In the present study, inflorescences in which only some of the styles were fully extended have been categorised as being "partially-open". Inflorescences with all styles erect, but not yet withered, have been classified as "fully-open". At Betty's Bay and Kirstenbosch, the numbers of partially- and fully-opened inflorescences were counted on randomly-selected flowering heads of *M. hirtus* during the study period.

The Birds

Male *P. cafer* weighed 38.2 ± 3.1 g, and had bill lengths of 29.1 ± 1.0 mm ($N = 6$), whereas corresponding values for *N. violacea* were 9.9 ± 0.6 g and 21.8 ± 0.9 mm ($N = 6$), respectively. Female birds were slightly smaller than males (Collins, unpublished data).

Patterns of floret opening

At Kirstenbosch, 12 marked inflorescences were observed over a period of eight days. During this time, florets with erect styles were counted at 07h30, 10h30, 13h30 and 16h30. Emergent styles were marked with a coloured felt pen to facilitate counting and subsequent identification. Data gathered were used to estimate diurnal changes in rates at which florets opened, and the time which elapsed between emergence of the first and last florets on each inflorescence.

Retention of pollen on pollen presenters

Pollen smears were taken from pollen presenters at known times after anthesis during experiments at Kirstenbosch. The technique used entailed rubbing a small cube of agar, impregnated with basic fuchsin, against all sides of each pollen presenter. Permanent mounts of cubes were examined microscopically, and the numbers of stained pollen grains counted in four randomly chosen $320 \times$ fields of view (Collins and Briffa, 1982). The presence of pollen was categorised as: +++ (> 60 pollen grains per $320 \times$ field

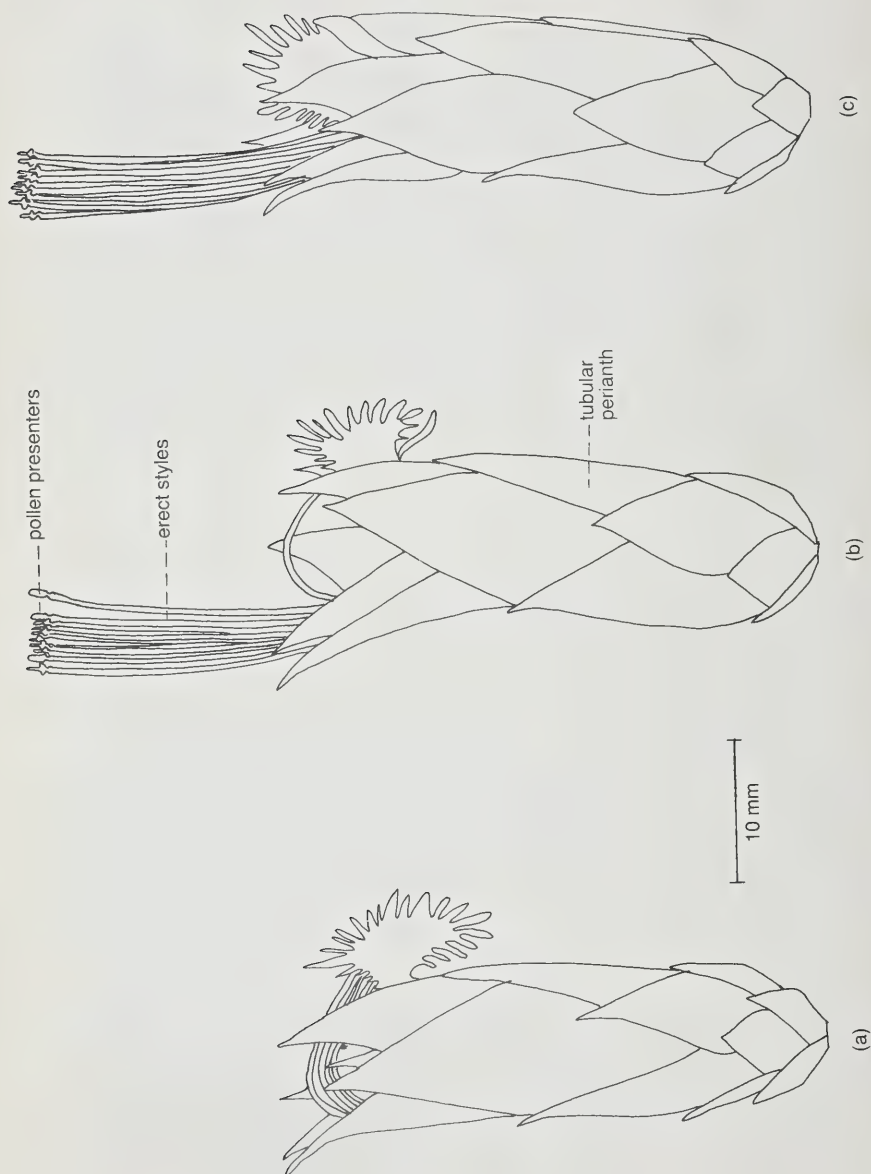


FIG. 1.

Inflorescence of *Mimetes hirtus*, showing florets at various stages of development; (a) unopened, (b) partially-opened, (c) fully-opened.

of view); ++ (10–60 grains per field); + (1–9 grains per field); and 0 (no pollen grains visible).

Additional evidence regarding temporal changes in pollen abundance on pollen presenters of *M. hirtus* was obtained by taking photo-micrographs of fresh terminal portions of styles at 0 and 2 days after anthesis, using a Leitz Laborlux II compound microscope and Wild Photoautomat MPS 45 unit.

Pollen viability

Several styles were collected immediately following anthesis and stored in clean, dry, sealed glass vials. Three pollen samples taken from these styles were smeared onto sterile 1.5 % tap water nutrient agar (Oxoid CM3) at 0, 2 and 5 days after collection. Each smear was examined daily for 5 days, and the percentage germination of pollen grains determined (Stanley and Linskens, 1974). Pollen viability was also tested for at 0 and 7 days by placing samples in drops of 4 % sulphuric acid and looking for signs of "germination" (Stanley and Linskens, 1974).

Nectar availability

Nectar standing crop volumes and percentage equivalent sucrose concentrations (w/w) were measured for individual inflorescences at 07h30, 10h30, 16h30 and 13h30 or 21h30 on two days at Betty's Bay, and four days at Kirstenbosch. On most occasions, five closed, five partially-opened and 10 fully-opened inflorescences were sampled. Volumes were measured using Drummond calibrated capillary tubes, and concentrations with a National temperature-compensated refractometer (Collins and Briffa, 1982; 1983).

Nectarivore foraging behaviour

At Betty's Bay, the manner in which *P. cafer* and *N. violacea* probed *M. hirtus* inflorescences was recorded at various times of day. Where possible, it was also noted whether the inflorescences visited were closed, partially-open or fully-open. No observations of this kind were possible at Kirstenbosch.

Pollen transfer by nectarivores

The relative importance of *P. cafer* and *N. violacea* as vectors of *M. hirtus* pollen, and the manner in which pollen transfer was effected, were assessed by examining smears taken from the foreheads, beaks and throats of birds caught in mist nets at Betty's Bay. Smears were prepared in essentially the same way as described earlier, and pollen grains counted after identification by comparison with those in smears taken from known plants (Collins and Briffa, 1982).

Effectiveness of pollination and seed set

Ten flowering heads of *M. hirtus* at Betty's Bay were enclosed with 10 mm mesh chicken wire to exclude *P. cafer* and *N. violacea*. Selection of flowering heads was such that none bore partially- or fully-opened inflorescences at the time of enclosure (August). In November, these heads were examined for evidence of seed set, as were another 10 heads that had not been screened from nectarivorous birds.

RESULTS

Floret opening

Rates at which florets on marked *Mimetes hirtus* inflorescences at Kirstenbosch produced erect styles are outlined in Table 1. There was a consistent trend over four days for highest rates to occur between 10h30 and 13h30, and lowest during the "overnight" period (Kendall's $W = 0,78$, $\chi^2 = 9,30$, $P < 0,01$). Only 12 of the marked inflorescences changed from being unopen to completely open during the study period. Of these, two opened in one to two days, two took almost eight days, and the remainder opened at fairly regular intervals between these times ($\bar{x} \pm SD = 4,3 \pm 2,1$ days).

TABLE 1.

Opening of *M. hirtus* florets on marked inflorescences at Kirstenbosch.

Date and parameter	Time of day			
	16h30–07h30 ("overnight")	07h30–10h30	10h30–13h30	13h30–16h30
9–10 August				
Inflor.	20	16	17	17
Florets opening	27	7	16	5
Florets per inflor. h	0,09	0,15	0,31	0,10
10–11 August				
Inflor.	17	15	17	17
Florets opening	7	0	15	7
Florets per inflor. h	0,03	0,00	0,29	0,14
11–12 August				
Inflor.	16	16	16	15
Florets opening	14	4	21	6
Florets per inflor. h	0,06	0,08	0,44	0,13
12–13 August				
Inflor.	13	13	13	11
Florets opening	0	8	15	1
Florets per inflor. h	0,00	0,21	0,38	0,03

The numbers of fully- and partially-opened inflorescences on 12 marked *M. hirtus* flowering heads at Kirstenbosch varied slightly during the study period, although values of 3.4 ± 2.3 and 1.7 ± 1.2 inflorescences per head respectively, on 9th August give a typical indication of relative abundance. Corresponding values for 39 marked flowering heads at Betty's Bay on 25th July were 4.5 ± 3.5 and 1.2 ± 1.7 inflorescences per head. Comparisons of equivalent values for the two sites show no significant differences, although there were always more fully- than partially-opened inflorescences present (Kirstenbosch: $t = 2.27$, $P < 0.05$; Betty's Bay: $t = 5.30$, $P < 0.001$).

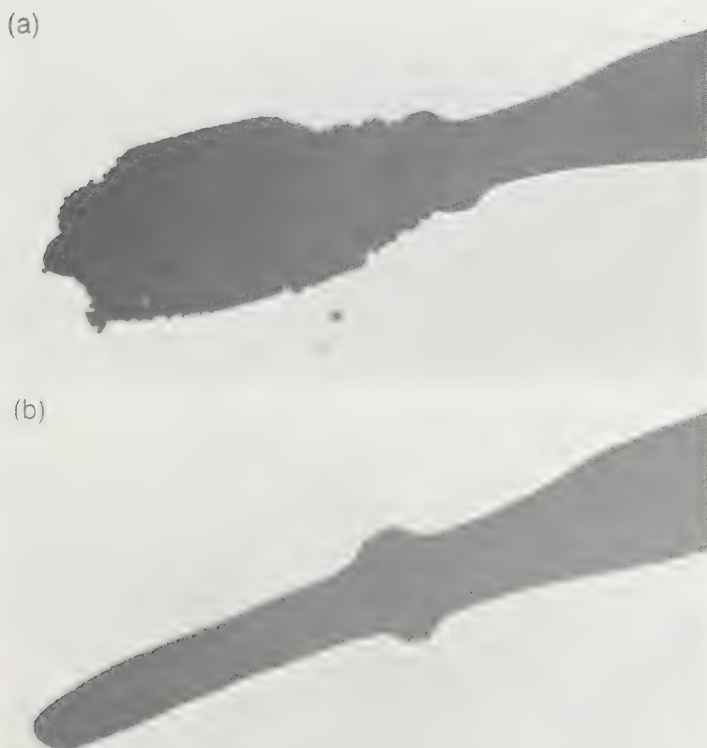


FIG. 2.
Terminal portions of *Mimetes hirtus* styles, showing pollen on pollen presenters (a) at time of anthesis, and (b) 2 days later. Magnification is $40\times$ natural size.

Retention of pollen on florets

Pollen is extremely abundant on freshly exposed pollen presenters of *M. hirtus* (Figure 2, Table 2). Exposure for 15 to 18 hours, however, reduced abundance significantly. After two to three days, there was virtually no pollen left on presenters at Kirstenbosch.

Pollen viability

Germination of freshly-released pollen on nutrient agar was approximately 30 % successful (Table 3). However, viability of pollen decreased significantly with age, with five-day-old pollen exhibiting only 3 % germination.

TABLE 2.
Presence of pollen grains in smears taken from pollen presenters of *M. hirtus*.

0	Time after exposure of pollen presenter (h)			
	0-3	3-6	15-18	>192
+++	+++	+++	++	+
+++	+++	+++	++	+
+++	+++	+++	++	+
+++	++	++	+	+
+++	++	++	+	0
+++	++	++	+	0
+++	++	++	+	0
+++	++	++	+	0

Five $320 \times$ microscopic fields of view were examined on each of 40 smears; +++ denotes an average of >60 pollen grains per field of a particular smear; ++ 10-60 grains per field; + 1-9 grains per field; 0 no grains visible.

TABLE 3.
Germination of *M. hirtus* pollen grains at intervals following exposure on pollen presenters.

Date trial initiated	% germination on day 1	% germination on day 3	% germination on day 6
17 August	0,0 \pm 0,0 (300)	33,3 \pm 2,7 (186)	28,9 \pm 3,8 (187)
19 August	0,0 \pm 0,0 (300)	16,7 \pm 10,9 (180)	.....
22 August	0,0 \pm 0,0 (300)	3,2 \pm 2,1 (181)	.....

Numbers in parentheses denote total pollen grains counted on each occasion (not all grains on agar plates counted).

A similar pattern was shown by data generated when fresh or seven-day-old pollen was placed in 4 % sulphuric acid. "Germination" was 84.7 ± 3.6 % successful in the first instance, and 4.8 ± 4.3 % in the latter (at least 200 pollen grains counted in each of the three samples for both treatments; $t = 24.68$; $P < 0.001$).

Nectar availability

Nectar standing crop volumes for partially- and fully-opened *M. hirtus* inflorescences at Betty's Bay are shown in Table 4. Values do not vary significantly from one time of day to another or between fully- and partially-opened inflorescences, except for volumes at 07h30 in partially-opened inflorescences, which are significantly greater than most other values ($P < 0.01$ for 5 out of 7 possible comparisons on 28th August).

At Kirstenbosch, standing crop volumes for unopened, partially- and fully-opened inflorescences were much greater than those at Betty's Bay, and showed no significant diurnal variations (Figure 3). Volumes were generally similar for the same types of inflorescences, at the same times of day, despite changes in air temperature and incidence of rain. Nevertheless, there was a consistent trend for smaller volumes to occur in fully- rather than partially-opened inflorescences (Mann-Whitney $U > 42$, $P < 0.05$, in 9 out of 14 possible comparisons; $t > 2.36$, $P < 0.05$, in 12 of the same comparisons). Volumes in unopened inflorescences were variable, usually being very small except in instances where the inflorescences opened readily when touched.

TABLE 4.
Nectar standing crop volumes ($\mu\ell$) for *M. hirtus* at Betty's Bay.

Date and condition of inflor.		Time of day				
		07h30	10h30	13h30	16h30	21h30
26 July	(a)	.....	.....	.....	.....	.....
	(b)	3.3 ± 8.4	0.8 ± 1.3	.....	4.1 ± 12.6	4.1 ± 7.6
28 Aug.	(a)	22.6 ± 21.9	3.8 ± 3.4	0.9 ± 1.0	2.1 ± 2.2	.....
	(b)	2.8 ± 5.3	4.1 ± 9.1	1.6 ± 2.6	0.8 ± 2.0	.....

Sample size was 12 in every instance; (a) and (b) denote partially- and fully-opened inflorescences, respectively.

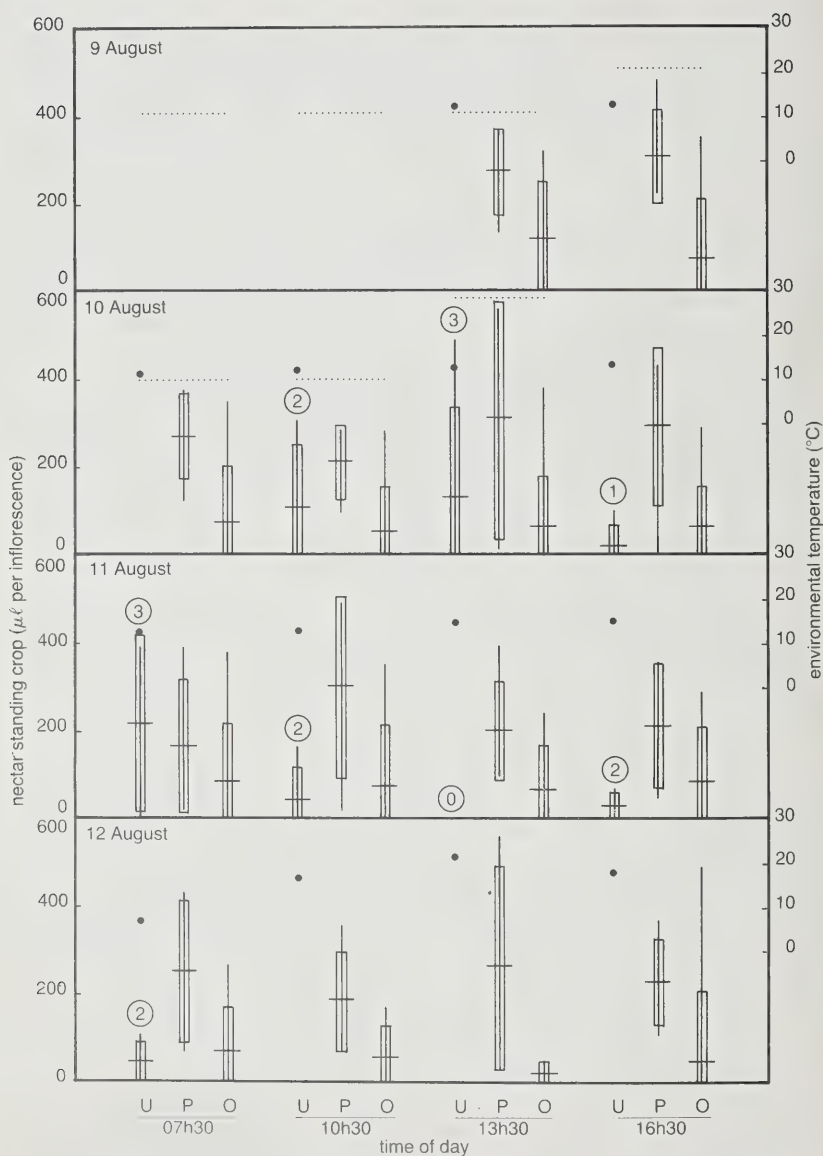


FIG. 3.

Additional measurements at Kirstenbosch showed that standing crop volumes varied according to the number of erect styles in partially-opened inflorescences ($323,1 \pm 172,1 \mu\ell$ when one to two styles erect, $183,6 \pm 93,4 \mu\ell$ when seven or more styles erect; $N = 10$ in each instance; $t = 2,25$; $P < 0,05$). Data used for this comparison were collected at 10h30, three days after the main experimental period, although overall volumes for the 20 inflorescences ($253,4 \pm 152,6 \mu\ell$) did not differ significantly from those indicated in Figure 3.

Few nectar concentrations were measured at Betty's Bay, but the values obtained ($16,1 \pm 1,6\%$, $N = 5$) were similar to those for Kirstenbosch (Table 5). There was a tendency for nectar concentrations at Kirstenbosch to be slightly greater for fully- than partially-opened inflorescences, although differences were not statistically significant.

Bird foraging behaviour

Without exception, *Promerops cafer* foraged on *M. hirtus* inflorescences at Betty's Bay while perching on top of the flowering heads (150 observations). Consequently, the birds had to reach over the distal ends of any erect styles in order to probe the inflorescences, thereby brushing their throats against the stigmas and pollen presenters. Fewer *Nectarinia violacea* were seen foraging on *M. hirtus* (20 observations), although all of these consistently perched to the side of, or beneath, the inflorescences that they probed. As a consequence, *N. violacea* rarely brushed against the stigmas or pollen presenters of erect styles.

It was not possible to watch individual *N. violacea* for long enough at Betty's Bay to ascertain whether they preferred *M. hirtus* inflorescences at particular stages of development. However, a territorial female *P. cafer* that could be watched for most of the day showed a clear preference for partially-opened inflorescences (unopened: 107 probes; partially-opened: 704 probes; fully-opened: 113 probes). It is not known whether this pattern is typical of *P. cafer*, in general. Nevertheless, the observed total numbers of inflorescences probed per flowering head by several *P. cafer* and *N. violacea* were significantly greater than the numbers of partially-opened inflores-

FIG. 3.

Nectar standing crop volumes for *Mimetes hirtus* inflorescences at Kirstenbosch. Vertical lines indicate ranges of values, horizontal lines means, and rectangles one standard deviation either side of the means. The letters U (sample size 5), P (sample size 5) and O (sample size 10) represent data for unopened, partially- and fully-opened inflorescences, respectively. Figures enclosed in circles denote the numbers of closed inflorescences that opened partly when touched. Symbols ● and . . . denote air temperatures and occurrence of rain, respectively, at various times of day.

TABLE 5.
Nectar concentrations (% w/w) for *M. hirtus* at Kirstenbosch.

Date and condition of inflor.		Time of day			
		07h30	10h30	13h30	16h30
9 Aug.	(a)	.....	.....	17,7 \pm 2,2 (6)	17,4 \pm 0,6 (5)
	(b)	.....	.....	16,7 \pm 3,1 (5)	21,0 \pm 4,3 (5)
10 Aug.	(a)	16,7 \pm 2,8 (5)	16,5 \pm 1,9 (5)	14,6 \pm 1,2 (4)	16,5 \pm 2,5 (4)
	(b)	18,8 \pm 2,6 (7)	16,6 \pm 1,9 (3)	15,8 \pm 1,0 (4)	14,8 \pm 4,5 (5)
11 Aug.	(a)	13,5 \pm 1,2 (5)	15,7 \pm 1,1 (5)	15,5 \pm 1,8 (5)	14,5 \pm 0,9 (5)
	(b)	18,0 \pm 5,9 (6)	16,0 \pm 1,7 (5)	16,2 \pm 2,1 (3)	16,5 \pm 2,4 (4)
12 Aug.	(a)	16,0 \pm 1,3 (5)	15,4 \pm 1,2 (5)	15,4 \pm 0,7 (5)	14,4 \pm 0,7 (5)
	(b)	16,8 \pm 1,2 (5)	19,6 \pm 3,8 (4)	20,3 \pm 5,5 (2)	18,8 (1)

(a) and (b) have same meanings as in Table 4. Sample sizes given in parentheses.

TABLE 6.
Comparison of observed abundances of inflorescences and nectarivore probing on flowering heads of *M. hirtus*.

	Partially-opened inflor. per head	Fully-opened inflor. per head	Inflor. probed per head by δ <i>P. cafer</i>	Inflor. probed per head by δ <i>N. violacea</i>
\bar{x}	1,2	4,5	3,6	3,0
SD	1,7	3,5	2,4	3,0
Range	0-7	0-14	1-11	1-5
N	39	39	67	28

TABLE 7.
Pollen carried by nectarivores at Betty's Bay.

Birds species	Sex and sample size	Pollen present on birds					
		Head		Other	Throat		
		M. hirtus	Erica sp.		M. hirtus	Erica sp.	Other
<i>Promerops cafer</i>	5 ♂ 3 ♀	61,2 ± 87,7 94,0 ± 85,0	0,0 ± 0,0 0,0 ± 0,0	0,2 ± 0,5 1,7 ± 1,5	44,0 ± 20,2 97,7 ± 38,6	0,0 ± 0,0 0,0 ± 0,0	0,4 ± 0,6 0,0 ± 0,0
<i>Nectarinia violacea</i>	7 ♂ 1 ♀	1,7 ± 1,1 1,0	1,1 ± 1,2 5,0	0,3 ± 0,5 0,0	3,0 ± 2,4 2,0	0,7 ± 1,0 13,0	0,0 ± 0,0 0,0

cences available per head at any given time (Table 6; *P. cafer*: $t = 5,49$, $P < 0,001$; *N. violacea*: $t = 3,12$, $P < 0,01$)

Pollen transfer

The majority of pollen grains collected from *P. cafer* and *N. violacea* at Betty's Bay were derived from *M. hirtus* (Table 7). Variability of pollen grain counts in different smears was considerable, although it is obvious that *N. violacea* carried significantly less pollen than *P. cafer*. Similar pollen loads were borne by head and throat regions, regardless of the nectarivore species involved.

Effective seed set

Seed set in 10 *M. hirtus* flowering heads to which nectarivores had access at Betty's Bay was relatively high, and significantly greater than in 10 heads enclosed by wire mesh (Table 8).

TABLE 8.
Seed set in *M. hirtus* at Betty's Bay.

Parameter	Exposed flowering heads	Enclosed flowering heads
Total inflorescences studied	107	121
Total inflorescences containing seed	38	1
% seed set	35,5	0,8

DISCUSSION

There has been a resurgence of interest in the pollination biology of plants in recent years (e.g. Faegri and van der Pijl, 1971; Heinrich, 1975; Wolf, 1975; Rourke and Wiens, 1977; Carpenter, 1978; Armstrong, 1979; Ford, Paton and Forde, 1979; Hopper, 1980; Frost and Frost, 1981; Collins and Briffa, 1982; Collins and Briffa, 1983). Much has been written regarding pollination and utilization of floral nectar by mammals, birds and invertebrates, although attention has also been paid to the significance of pollen transfer in terms of gene flow and plant population structure (e.g. Beattie, 1978; Levin, 1978).

Despite the general interest shown in pollination in other parts of the world, relatively little attention has been paid to this aspect of plant biology in southern Africa. Virtually the only major studies in this area have concerned the pollination of various *Protea* species (Rourke and Wiens, 1977;

Wiens *et al.*, 1982), and *Strelitzia nicolai* (Frost and Frost, 1981). In the latter case, a variety of sunbirds (Nectarinidae) appear to be the major pollen vectors and users of floral nectar. Some *Protea* species are also pollinated by sunbirds and Cape Sugarbirds, although rodents appear to transfer pollen in many instances. Invertebrates do not seem to play a vital role for any of these plants, although they may do so in other groups.

It has been suggested that members of the Proteaceae such as *Mimetes* are pollinated primarily by birds (Skead, 1967; Rourke, 1982). Qualitative data have not been published previously in support of this contention, although it is obvious that inflorescences of members of this genus have many features that are allegedly characteristic of bird-pollinated plants: bright colouration, ease of access from above, diurnal availability of nectar and tubular perianths (Faegri and van der Pijl, 1971; Carpenter, 1978; Hopper, 1980). Direct observations made in the present study, however, confirm that, at least at Betty's Bay, *Promerops cafer* and *Nectarinia violacea* are frequent visitors to *Mimetes hirtus*. Intermittent observations of inflorescences during the day and at night failed to detect any mammalian visitors. The only invertebrates present were small Hemiptera (2.7 ± 2.5 per inflorescence, $N = 10$), and these appeared to be confined to perianth tubes, rarely moving on to the styles (Collins, unpublished data).

Evidence obtained at Betty's Bay during the present study demonstrates that *P. cafer* is a major pollen vector for *M. hirtus*, although *N. violacea* appears to be much less important. This difference could be a function of the strongly territorial behaviour of *P. cafer*, which allows *N. violacea* relatively few opportunities to probe inflorescences. It is likely, however, that differences in foraging behaviour are more important. As the subordinate nectarivore, *N. violacea* is probably forced to rely on fully-opened inflorescences, with their relatively low nectar rewards. Consequently it would only rub its head and throat against dehiscent anthers. The existence of substantial pollen loads on both throats and heads of *P. cafer* is consistent with the foraging behaviour of this species, particularly as its preference is for partially-opened inflorescences in which it could presumably induce anthesis as its head brushed against unopened florets. The significance, if any, of higher rates of floret opening between 10h30 and 13h30 is not apparent.

M. hirtus is protandrous, with pollen exposure on a given floret occurring before the stigmatal groove is receptive (Rourke, personal communication). Effective transfer of pollen between one floret and another is therefore dependent upon vectors such as *P. cafer* brushing against pollen presenters and stigmata at appropriate stages in their development. Pollen availability on individual presenters decreases significantly within 15 h of anthesis, even at sites such as Kirstenbosch where nectarivores rarely visit *M. hirtus*. However, it takes several days for all florets on an inflorescence to open, thereby

extending the duration of pollen-availability on the inflorescence. Nevertheless, viability of any pollen that remains on pollen presenters is reduced significantly after two days. It is obvious, therefore, that effective outcrossing is unlikely unless vectors visit inflorescences that are partially- or just completely-opened. In this context, it would seem significant that *P. cafer* has a definite preference for partially-opened inflorescences, although it sometimes probes others. It is not known when the stigmatal grooves of *M. hirtus* are receptive, although this would most appropriately occur when birds are visiting inflorescences on which most of the florets were open.

Partially-opened *M. hirtus* inflorescences at Kirstenbosch produce standing crop volumes of relatively dilute nectar that are larger than most values reported for other plants (e.g. Ford, 1979; Frost and Frost, 1981; Collins and Briffa, 1982; 1983). There is no significant variation from one time of day to another, possibly because nectarivores rarely visit the inflorescences. With few exceptions, unopened and fully-opened inflorescences contain little nectar. These observations suggest that nectar production by *M. hirtus* varies according to the age of the inflorescences, a trend similar to that reported for several other plant species (e.g. Frost and Frost, 1981). Standing crops at Betty's Bay are much smaller than at Kirstenbosch, possibly because of differences in soil water potential (Fagan, 1973; Boucher, 1978) and greater nectar demand by *P. cafer* and *N. violacea*. At this site, nectarivore pressure during the day is almost certainly responsible for the lack of significant differences between standing crops for partially- and fully-opened inflorescences at all times except shortly after dawn (07h30). This explanation is consistent with the observed foraging preference of *P. cafer* for partially-opened inflorescences.

The *M. hirtus*-*P. cafer* system is clearly well adapted for pollen transfer. Nectar rewards are greatest in inflorescences that are releasing pollen, thereby attracting *P. cafer* at a time when maximum pollen transfer can occur. The effectiveness of this system is demonstrated by the relatively high level of seed set that results from exposure of *M. hirtus* to *P. cafer* (and *N. violacea*). Restriction of *M. hirtus* to small isolated populations in the south-west Cape would not seem to be caused by any deficiencies in this system, but rather because of the need for habitats containing acidic, peaty soils (Rourke, personal communication) and/or the territorial nature of the major pollinator, *P. cafer*.

ACKNOWLEDGEMENTS

Funds provided by the Fynbos Biome Project, Jack Niven Foundation and University of Cape Town supported this study, while the author was on sabbatical leave from the Western Australian Institute of Technology. Pro-

fessor H. B. Rycroft and Mr. J. Winter kindly gave permission for some of the work to be conducted at Kirstenbosch National Botanic Gardens. Mr. R. Attwell and other councillors gave permission for field studies to be conducted within the Municipality of Betty's Bay. Valuable assistance with field work was given by Mrs. L. Collins and Mr. R. Collins. Mr. D. Gerneke helped with photo-micrography, and Professor D. Mitchell provided facilities and materials required for culturing pollen grains. Dr. J. Rourke gave valuable guidance throughout the study, and helped arrange accommodation at the Harold Porter Lodge at Betty's Bay. Dr. Rourke and Professor W. R. Siegfried made constructive comments on a draft of the manuscript.

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NEW XANTHOPARMELIAE (LICHENES) FROM SOUTHERN AND CENTRAL AFRICA

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ABSTRACT

Ten new species of *Xanthoparmelia* are described from southern and central Africa, and one new combination in the genus is proposed. The new species are *X. aggregata* Knox, *X. cedrus-montana* Brusse, *X. dysprosa* Brusse et Knox, *X. ianthina* Brusse, *X. karoo* Knox et Brusse and *X. leucostigma* Brusse from the Karoo and Western Cape, *X. cylindriloba* Knox and *X. hedbergii* Knox from Kenya, *X. fucina* Knox from Zimbabwe and *X. walteri* Knox from South West Africa/Namibia. The new combination is *X. exornata* (Zahlbr.) Brusse et Knox from the Karoo.

UITTREKSEL

NUWE XANTHOPARMELIAE (LICHENES) VAN SUIDELIKE EN SENTRAAL AFRIKA

Tien nuwe soorte van *Xanthoparmelia* van suidelike en sentraal Afrika word beskryf, en een nuwe kombinasie in die genus word voorgestel. Die nuwe soorte is *X. aggregata* Knox, *X. cedrus-montana* Brusse, *X. dysprosa* Brusse et Knox, *X. ianthina* Brusse, *X. karoo* Knox et Brusse en *X. leucostigma* Brusse van die Karoo en Westelike Kaap, *X. cylindriloba* Knox en *X. hedbergii* Knox van Kenia, *X. fucina* Knox van Zimbabwe en *X. walteri* Knox van Suidwes Afrika/Namibia. Die nuwe kombinasie is *X. exornata* (Zahlbr.) Brusse et Knox van die Karoo.

INTRODUCTION

Lichens now placed in the genus *Xanthoparmelia* were first recognised as a distinct group by Nylander (1860), who placed them in his "Stirps Parmeliae conspersae". The distinction was further consolidated by Wainio (1890), who coined the name *Xanthoparmelia* for this section of the subgenus *Euparmelia* Nyl., placing in the section all narrow-lobed yellow-green species (containing the pigment usnic acid in the upper cortex). In elevating the group to subgeneric status Hale, in Hale and Kurokawa (1964), employed substrate ecology, rhizine morphology and the absence of cilia to refine Wainio's (1890) concept, and this interpretation was retained when Hale (1974)

Accepted for publication 25th October, 1982.

raised the group to generic status. This final step has been rejected by Beltman (1978), Krog and Swinscow (1979), Hawksworth *et al.* (1980), Elix (1981) and Poelt and Vězda (1981), although Krog and Swinscow (1979) and Elix (1981) accept the subgeneric ranking. Elix (1981) pointed out that in the genera *Xanthoparmelia*, *Pseudoparmelia* and *Neofuscelia*, all genera which have been segregated from *Parmelia* *sensu lato*, striking morphological parallels may be found, the generic segregation in such cases being effectively based solely on the chemical constituents present in the upper cortex. This may be argued to be inadequate grounds, and certainly suggests that additional criteria must be sought and considered in an attempt to resolve this problem.

In the present paper, no attempt is made further to consider this question, but *Xanthoparmelia* is recognised at generic level because of the distinctive morphology of the majority of species, because of its ability to survive and grow in arid conditions, and because of its characteristic tendency, by comparison with the other two genera mentioned above, to produce luxuriant growth in moister environments.

The following species have been described from specimens collected from the Karoo and adjacent regions by one author (F.A.B.) during the course of a taxonomic investigation into the genus presented for the degree of M.Sc. at the University of the Witwatersrand, and from specimens seen by the other author at the Smithsonian Institution, Washington, D.C., while on extended study leave from the same University.

***Xanthoparmelia aggregata* Knox, sp. nov. Fig. 1.**

Thallus sordide flavescenti-virescent, stellatus, usque ad 50 mm diametro, terricola, laxe affixus. Lobi 0,5–1,5 mm lati, ligulati vel canaliculati, ramosi, abrupte decrescentibus apicem versus. Pagina infera concolora vel quam pagina superior parum fuscans, maculae aliquot atrantes, cum rhizinis plerumque consociatae, exclusae. Isidiis sorediisque carens. Cortex superior 40–50 μm crassus, stratum gonidiale 60–65 μm crassum, sed stratum gonidiale 18–20 μm crassum cum pagina infera concolora consociatum, medulla alba 220–240 μm crassa, cortex inferior 18–20 μm crassus. Apothecia pycnidiaque ignota, sed perithecia parasitica adsunt.

Cortex superior K non reagens (acidum usnicum continens), medulla alba K straminea; C, KC pallide rosea, P non reagens (acidum evernicum continens).

Typus: CAPE—3118 (Vanrhynsdorp): Salt River (-BC), van Rhyn's Dorp Division (Cape Province), on ground, Sept., 1941, *Stokoe 7721* (BOL, holotype; US, isotype).

OTHER SPECIMEN SEEN

N. S. Pillans s.n., January 1928 (BOL).

Xanthoparmelia aggregata is a member of the *X. amphixantha* (Müll. Arg.) Hale morphological group, based on an Australian species, *X. amphixantha*, containing stictic, norstictic and constictic acids, and including *Parmelia* (*Xanthoparmeliā*) *pseudoamphixantha* Elix (norstictic and conorstictic acids), *P. (X.) reptans* Kurok. (fumarprotocetraric and succinprotocetraric acids) and *P. (X.) willisii* Kurok. (fumarprotocetraric, succinprotocetraric and protocetraric acids). From South Africa *X. subflabellata* (Steiner) Hale contains stictic, norstictic and constictic acids, and may well be synonymous with *X. amphixantha*.

All the above lichen acids are β -orcinol depsidones, which is the most common group of such substances in the genus *Xanthoparmelia*. *Xanthoparmelia aggregata*, however, contains evernic acid, an orcinol p-depside, which although not closely related to the β -orcinol depsidones, is clearly simpler in structure, and could therefore be considered to be more primitive. Other orcinol p-depsides found in *Xanthoparmelia* species are lecanoric acid, found in *X. worcesteri* (Steiner et Zahlbr.) Hale, *X. joranadia* (Nash) Hale, *X. arida* Egan et Derstine and *X. lecanorica* (Hale) Hale, and gyrophoric acid, found in *X. leucostigma* Brusse, described later in this paper. Evernic acid is found also in *X. dysprosa* Brusse et Knox, another new species described herein. This small proportion, 8 out of approximately 170 species, emphasises the relative rarity of these substances in *Xanthoparmelia*, but the scattered distribution—*X. joranadia* and *X. arida* in North America and the remainder in South Africa—together with the considerable diversity of thallus morphology in these species, does not permit any simple explanation of their occurrence. It appears that orcinol p-depsides must have arisen independently on a number of occasions.

***Xanthoparmelia cedrus-montana* Brusse, sp. nov. Fig. 2.**

Thallus foliosus, nitidus vel sordide flavovirens, laxe vel moderate adnatus, saxicola, usque ad 100 mm diametro. Lobi sublineares vel elongati, imbricati, 0,3–2,0 mm lati, leviter vel valde albomaculati. Pagina infera nigra, rhizinis absentibus vel moderate abundantibus. Isidiis sorediisque carens. Cortex superior 25–50 μ m crassus, stratum gonidiale discontinuum, 0–50 μ m crassum, medulla alba 100–200 μ m crassa, cortex inferior 15–20 μ m crassus. Apothecia cupulis vadosis, substipitata, usque ad 6 mm diametro, rara. Hymenium 40–60 μ m crassum, subhymenium 10–20 μ m crassum, excipulum 30–60 μ m crassum. Sporae 8, 8,0–12,0 \times 4,5–7,0 μ m. Pycnidia 100–150 μ m diametro, pycnidiosporae non visae.

Cortex superior K non reagens (acidum usnicum continens), medulla alba K aurea sed armeniacescens, C non reagens, P aurantiaca (acidum thamnolicum continens).

Typus: CAPE—3319 (Worcester): Ceres (-AD), June 1924, T. B. Leslie 476 (TUR-V 34575).

OTHER SPECIMEN SEEN

Brusse 772-8-2-19, 8/2/77 (J).

The holotype specimen is annotated, apparently by Leslie, as "var. *hypomelaena* Vainio", referring to *Parmelia stenophylla* f. *hypomelaena* Vainio ex Lynge (1937), as annotated by Hale. The epithet *hypomelaena* is, however, unavailable in *Xanthoparmelia* at the specific level, having been used by Hale (1974).

This further addition to the *X. hypoleia* (Nyl.) Hale complex appears to be restricted in distribution to the Cedarberg Range in the Western Cape. A further survey carried out in 1981 produced no additional material.

The *X. hypoleia* complex includes at present specimens known to contain at least 11 different medullary substances, distributed between 9 species, including the three in the present paper. Relationships between these have been discussed (Knox, 1981), and will be the subject of a later publication.

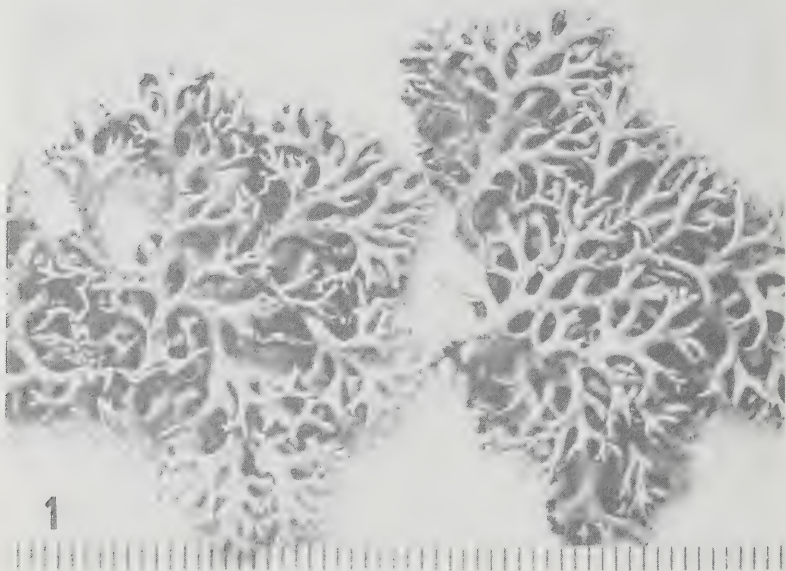


FIG. 1.
Xanthoparmelia aggregata Knox (holotype). Scale in mm.

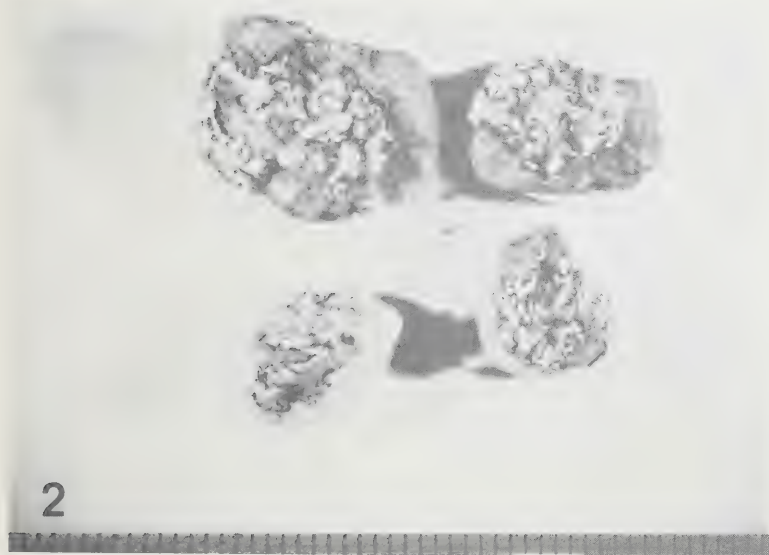


FIG. 2.

Xanthoparmelia cedrus-montana Brusse (holotype). Scale in mm.

***Xanthoparmelia cylindriloba* Knox. sp. nov. Fig. 3.**

Thallus terricola, pallide flavovirens vel atrans. Lobi 0.5–1.5 mm lati, plus minusve cylindrici post substitutionem inferiori cortici superiore cortice. Pagina infera nigra, rhizinis nigris caespitosis. Isidiis sorediisque carens. Cortex superior 25–30 μ m crassus, stratum gonidiale 40–50 μ m crassum, medulla alba 320–520 μ m crassa, cortex inferior 20–25 μ m crassus. Apothecia pycnidiaque ignota.

Cortex superior K non reagens (acidum usnicum continens), medulla alba K flavescens tum sanguinea, C non reagens, P aurantiaca (acidum salazinicum et acidum norsticticum minutissimum continens).

Typus: KENYA COLONY: Mt. Kenya, Teleki Valley, alpine region, in the uppermost part of the valley, on frost-lifting ground, 4 200 m. 27/7/1948, *Hedberg s.n.*, Flora Africana 1705 (UPS, holotype; US, isotype).

OTHER COLLECTION

TANGANYIKA TERRITORY: Kilimanjaro, above Peters Hut, 3 970 m 23/6/1948, *Hedberg s.n.*, Flora Africana 1354 (UPS).

Xanthoparmelia cylindriloba is a very distinctive species with erect, more or less cylindrical lobes, growing on soil. In both the specimens examined,

these lobes were separate, and it may be that in younger specimens a basal, broad-lobed region also occurs. No evidence of such lobes could, however, be found.

Although many species of *Xanthoparmelia* contain salazinic acid, the distinctive morphology of *X. cylindriloba* clearly separates it from other species in the genus.

***Xanthoparmelia dysprosa* Brusse et Knox, sp. nov. Fig. 4.**

Thallus sordide flavescenti-virescens, saxicola, laxe adnatus vel pulvinatus. Lobi lati tum divaricate ramosi lineares 0,5–1,5 mm in latitudinem, valde albomaculati. Isidiis soredisque carens. Pagina infera nigra, nuda vel sparsim rhizinata. Cortex superior 14–17 μm crassus, stratum gonidiale interruptum, 60–65 μm crassum, medulla alba 120–130 μm crassa, cortex inferior 16–18 μm crassus. Apothecia dispersa, usque ad 12 mm diametro, cupulata demum aperientia. Hymenium 50–55 μm crassum, subhymenium 40–45 μm crassum, excipulum 260–310 μm crassum. Sporae non visae.

Cortex superior K non reagens (acidum usnicum continens), medulla alba K non reagens, C non reagens, KC pallide rosea (acidum evernicum continens).

Typus: CAPE—3318 (Cape Town): Platteklip, Vlottenberg (-AD), on granite rock, *S. Garside 5035(a)* (BOL, holotype; US, isotype).

OTHER SPECIMEN SEEN

CAPE—3218 (Clanwilliam): 25 km south of Clanwilliam, Olifants River Valley (-BD), on TMS, alt. 400–600 m, *Brusse 772 8–1–6*.

Xanthoparmelia dysprosa is the seventh species in the *X. hypoleia* complex, which includes *Parmelia* (*Xanthoparmelia*) *burmeisteri* Elix, *X. hypoprotocetrarica* (Kurok. et Elix) Hale, *X. notata* (Kurok.) Hale, *P. (Xanthoparmelia) pseudohypoleia* Elix, *X. cedrus-montana*, described above, and *X. karoo* Knox et Brusse and *X. leucostigma* Brusse, described later. Within the group there is considerable uniformity of morphology between species, although some small variations in lobe size do occur.

The chief common characteristic is the effigurate maculate appearance of the upper surface, and differentiation between species is based primarily on the different chemical constituents found in the medulla. In *X. dysprosa* is found the relatively uncommon (in *Xanthoparmelia*) orcinol p-depside, evernic acid, while *P. burmeisteri* contains the β -orcinol p-depsides barbatic and 4-O-demethyl barbatic acids. Four other species, *X. hypoleia*, *X. hypoprotocetrarica*, *X. karoo* and *P. pseudohypoleia* contain related β -orcinol depsidones, and *X. notata* contains the "mixed" depsidone, notatic acid. A further orcinol p-depside, gyrophoric acid, has been found in *X. leucostigma*, described subsequently.

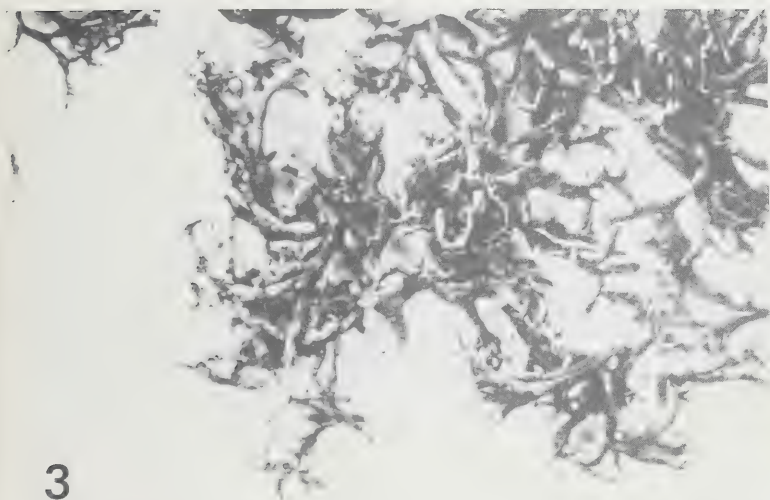


FIG. 3.
Xanthoparmelia cylindriloba Knox (holotype).



FIG. 4.
Xanthoparmelia dysprosa Brusse et Knox (holotype). Scales in mm.

Xanthoparmelia exornata (Zahlbr.) Brusse et Knox, comb. nov. **Fig. 5.**
Basionym: *Parmelia conturbata* var. *exornata* Zahlbruckner (1932) Ann.
Crypt. Exot. 5: 251–252.

Typus: CAPE—Namaqualand: Steinkopf, Leg. Pastor G. Mayer, *P. A. v. d. Bijl* 950
(W(1934) 315, holotype!; STEU, isotype).

Thallus foliose, loosely to tightly adnate on rock, up to 100 mm across. Lobes plane to more usually strongly convex, sublinear to elongate, discrete to imbricate, 1–3 mm broad, leathery. Upper surface yellowish green, darkening towards the centre, strongly maculate to almost pseudocyphellate in regions where the epicortex is highly pored. Lower surface pale brown, moderately rhizinate. Upper cortex very uneven, 10–250 μm thick; algal layer discontinuous, up to 100 μm thick; medulla 100–600 μm thick; lower cortex 20–40 μm thick. Apothecia sparse to moderately abundant, substipitate, up to 7 mm in diameter, shallowly cupped. Hymenium 40–60 μm thick, subhymenium 5–15 μm thick, exciple 30–120 μm thick. Ascospores 8, 7, 0–11, 0 \times 5, 0–6, 5 μm . Pycnidiospores 5–8 μm long.

Upper cortex K^- (usnic acid), medulla K^+ yellow turning red (salazinic acid usually together with the chalybaeizans unknown).

This very distinctive species is widespread in the Karoo, but shows no close relationships with any other Xanthoparmeliae. All the other strongly maculate species are in the *X. hypoleia* complex, and have narrower, more linear lobes, with a black undersurface and sparse rhizines. *X. exornata* represents the extreme state of the effigurate maculate condition found in the *X. hypoleia* complex and in *Omphalodium hottentottum* (Ach.) Flot. In *X. exornata* the epicortical pores are closely aggregated, and may weather to produce discontinuities which resemble pseudocyphellae, but as pointed out by Hale (1981), investigation of the development of these structures will reveal their true nature.

Xanthoparmelia fucina Knox, sp. nov. **Fig. 6.**

Thallus sordide flavescenti-virescent, saxicola adnatus vel laxe adnatus, centrum versus dense isidiatus. Lobi subirregulares, aliquantum dissecti, 0,7–2,0 mm lati. Pagina infera pallide castanea, interdum apices versus atrans. Rhizinae moderate abundantes cum pagina infera concolorae. Isidia plerumque simplicia, 0,1–0,3 \times 0,2–0,7 mm. Cortex superior 18–20 μm crassus, stratum gonidiale 30–35 μm crassum, medulla alba 75–90 μm crassa, cortex inferior 10–12 μm crassus. Apothecia non visa.

Cortex superior K non reagens (acidum usnicum continens), medulla K , P aurantiaca (acidum protocetraricum et maculae irregulares rhodophyscinae continens).

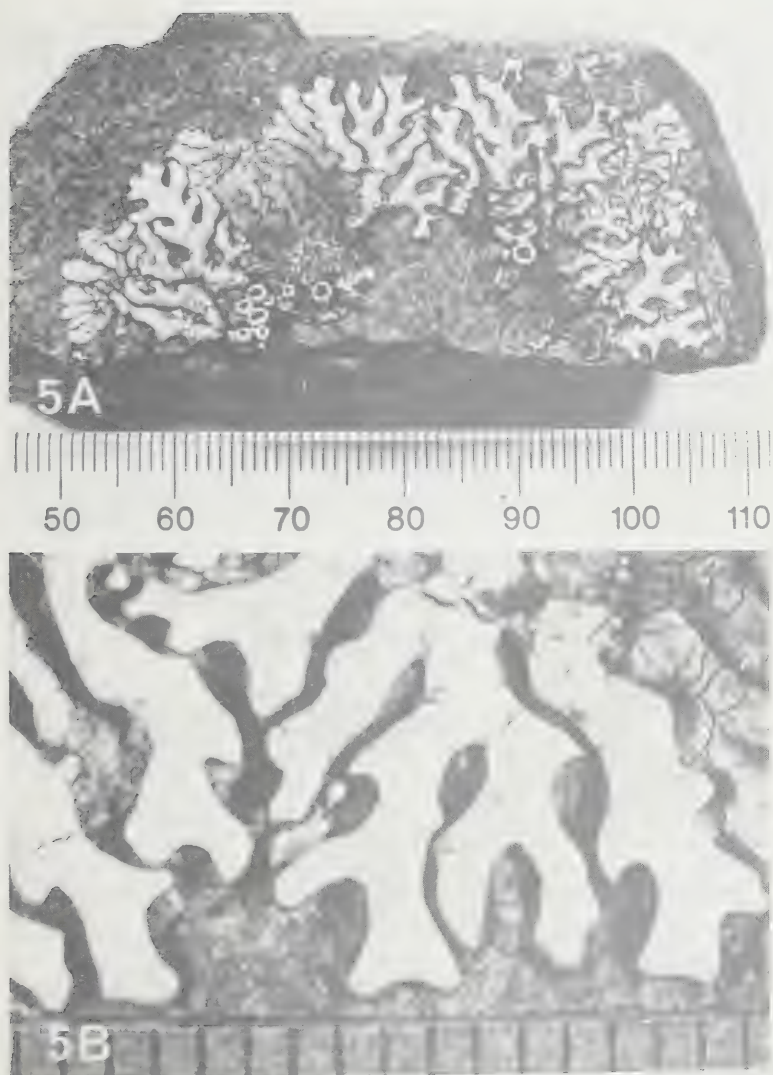


FIG. 5.

Xanthoparmelia exornata (Zahlbr.) Brusse et Knox. A. Typical growth form; B. The maculate upper surface. Scales in mm.

Typus: ZIMBABWE: World's View, Matopos, S Rhodesia, common on vertical to horizontal granite faces, usually east aspect, 9 vii 1946, E.A. Schelpe 1591 (BOL, holotype; US, isotype).

Xanthoparmelia fucina is similar in form to *X. subramigera* (Gyel.) Hale, but differs in having slightly narrower lobes, and in containing protocetraric acid, rather than fumarprotocetraric and succinprotocetraric acids. Also similar morphologically is *X. weberi* (Hale) Hale, which has narrower lobes, smaller isidia and contains hypoprotocetraric acid. No sexual (apothecial) counterpart for *X. fucina* has been found.

***Xanthoparmelia hedbergii* Knox, sp. nov. Fig. 7.**

Thallus sordide flavescenti-virescens, saxicola, arcte adnatus, transverse rimosus vel centrum versus aliquantum areolatus. Lobi sublineares, 0,5–1,0 mm lati, pagina infera pallida vel badia, rhizinis paene apicibus; rhizinae cum pagina infera concolorae. Isidia cylindrica vel parum inflata, 0,05–0,1 × 0,1–0,3 mm abundantia sed non densa. Cortex superior 15–20 µm crassus, stratum gonidiale 30–35 µm crassum, medulla alba 100–130 µm crassa, cortex inferior 10–12 µm crassus. Apothecia non visa.

Cortex superior K non reagens (acidum usnicum continens), medulla alba K non reagens, C non reagens vel pallide rosea, KC pallide rosea, P non reagens (acidum hypoprotocetraricum continens).

Typus: KENYA: Rift Valley, S of Lake Naivasha, Olkaria area, near stream exit on recent lava flow, c2000 m, 5 iv 1976, O. Hedberg s.n., Flora of Kenya 6204d (UPS, holotype; US, isotype).

Xanthoparmelia hedbergii is morphologically close to *X. neocongensis* (Hale) Hale and to *X. weberi*, and all three species contain hypoprotocetraric acid. Lobe size in *X. neocongensis* and *X. hedbergii* are in the same range, but the former species is distinguished by having a black lower surface. Lobes in *X. weberi* are broader than those in *X. hedbergii*. Although lobe size is influenced by environment, no tendency to a reduced lobe width could be found in South African populations of *X. weberi*, even in adverse conditions. On this basis, *X. hedbergii* is recognised as distinct from *X. weberi*, and is assumed to have a more northerly distribution.

***Xanthoparmelia ianthina* Brusse, sp. nov. Fig. 8.**

Thallus foliosus, flavovirens vel olivaceus, saxicola moderate adnatus, usque ad 60 mm in diametro. Lobi sublineares, 0,5–2,0 mm lati; cortice superiore fatiscenti medulla ianthina revelata. Isidiis sorediisque carens. Pagina infera pallide spadicea, rhizinis sparsis vel moderate abundantibus. Cortex superior 12–20 µm crassus, stratum gonidiale 20–50 µm crassum, medulla 20–140 µm crassa, cortex inferior 5–15 µm crassus. Apothecia rara,

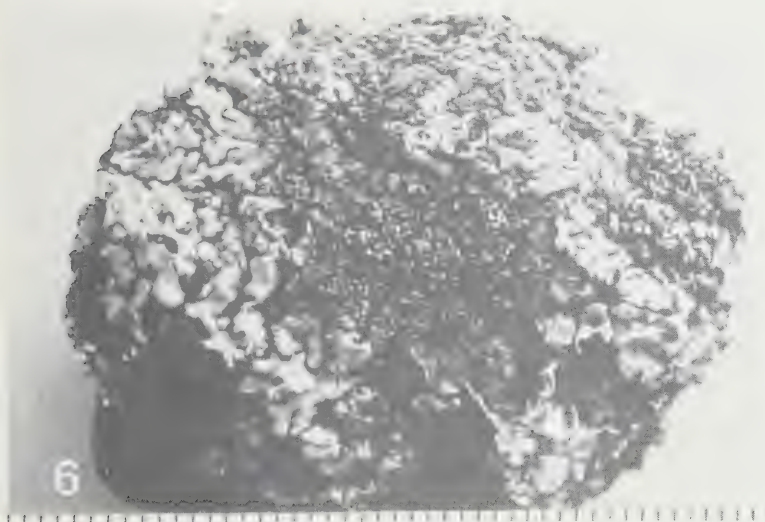


FIG. 6.
Xanthoparmelia fucina Knox (holotype).

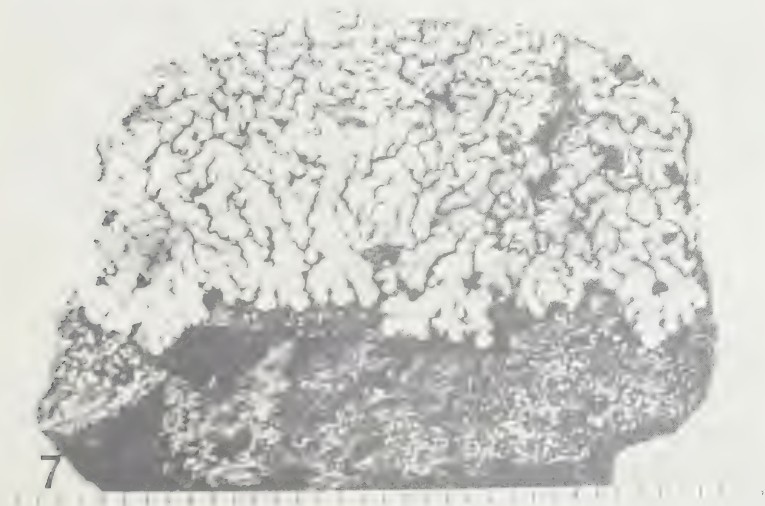


FIG. 7.
Xanthoparmelia hedbergii Knox (holotype). Scales in mm.

substipitata, usque ad 2,5 mm in diametro cupulis vadosis. Hymenium 40–60 μm crassum, subhymenium 20 μm crassum, excipulum 20–30 μm crassum. Sporae 8, 7,0–11,0 \times 4,0–6,5 μm ; pycnidiosporae 5,0–7,0 μm longae.

Cortex superior K non reagens (usnic acid continens), medulla ianthina, K intense purpurea (pigmenta anthraquinonica et materia ignota continens).

Typus: CAPE—3119 (Calvinia): 42 km NE of Vanrhynsdorp, Vanrhyn's Pass (-AC), on TMS, alt 460–610 m, *Brusse* 768–10–1–15.

This species closely resembles *X. endomiltodes* (Nyl) Hale, but differs in lacking salazinic acid and in containing two unknown substances, designated Th-1 and Th-2. These two substances are suspected β -orcinol m-depsides, exhibiting the following characteristics. Th-1 is K^+ yellow, rapidly becoming bright orange-red. On thin-layer chromatography (TLC) plates developed in 10 % sulphuric acid it is olive to brown, whereas Th-2 is olive to greyish. Th-1 is yellow-brown to brown in long-wave (366 nm) uv light, and Th-2 is brown. Table 1 gives TLC data for these two substances in comparison with the standards atranorin and norstictic acid, expressed in the format employed by Culberson (1972).

Microhydrolysis of Th-1 according to the method described by Culberson (1972), and using for comparison baeomycesic acid obtained from *Siphula torulosa* (Thunb. ex Ach.) Nyl. indicated that the A-ring in both cases was (after oxidation by sulphuric acid during the hydrolysis procedure) 4–0-methyl–3–carboxyorskellinic acid. No second subunit could be detected from this procedure, and it was assumed to have remained at the origin.

Xanthoparmelia karoo Knox et Brusse, sp. nov. Fig. 9.

Thallus foliosus, saxicola, moderate vel arcte adnatus, usque ad 60 mm in diametro. Lobi 0,8–1,5 mm lati, convexi, lineares vel sublineares, unifor-

TABLE 1.

TLC data for the two suspected m-depsides Th-1 and Th-2, using norstictic acid and atranorin as standards.

Lichen substance	R_f class Solvents			$R_f \times 100^a$ Solvents		
	A	B	C	A	B	C
Th-1	4	1–2	3	40/40,75 (56)	6/39,73 (56)	18/34,77 (55)
Th-2	3	1	1–2	21/35,72 (54)	0/35,65 (49)	6/32,77 (54)

^a The $R_f \times 100$ value is given, followed by a virgule, and then the $R_f \times 100$ values for norstictic acid and atranorin, with the mean of these two in parentheses.

miter appressi, dilute vel manifeste albomaculati. Pagina infera nigra, grosse rhizinata. Isidiis sorediisque carens. Cortex superior 20–100 μm crassus, stratum gonidiale 40–80 μm crassum, medulla alba 50–500 μm crassa, cortex inferior 30–60 μm crassus. Apothecia sparsa vel moderate abunda, substipitata, usque ad 5 mm diametro, cupulis vadosis. Hymenium 40–60 μm crassum, subhymenium 5–10 μm crassum, excipulum 30–60 μm crassum. Ascospores 8, 8,0–13,0 \times 4,0–6,0 μm . Pycnidia 100–200 μm diametro, pycnidiosporae 5,0–8,0 μm longae.

Cortex superior K non reagens (acidum usnicum continens), medulla K non reagens, C pallide rosea, KC rosea (acidum hypoprotocetraricum continens, aliquando acido 4–0-methylhypoprotocetrarico).

Typus: CAPE—3219 (Wuppertal): 32 km NE of Clanwilliam, Klipfonteinrand (-AA), on TMS, alt. 300–450 m, *Brusse* 768–10–3–7 (J, holotype).

Morphologically, *X. karoo* resembles *X. exornata*, but is less distinctly maculate. The medullary chemistry is identical to that of *X. hypoprotocetrarica*, but the latter species is less adnate, has broader lobes and usually exhibits a denser, more imbricate or even pulvinate growth form. In lobe form, *X. karoo* may be considered as part of the *X. hypoleia* complex, but is distinguished from the other members of this group by its closely adnate mode of growth.

***Xanthoparmelia leucostigma* Brusse, sp. nov. Fig. 10.**

Thallus sordide flavovirescens, saxicola, moderate vel arcte adnatus. Lobi lineares, plani vel convexi, uniformiter appressi, contigui, 0,5–3,0 mm lati, albomaculati. Pagina infera eborina vel pallide fusca, moderate rhizinata, rhizinis grossis. Isidiis sorediisque carens. Cortex superior 15–70 μm crassus, stratum gonidiale irregulare, 40–80 μm crassum, medulla 60–200 μm crassa, cortex inferior 15–30 μm crassus. Apothecia sparsa vel moderate numerosa, substipitate, usque ad 3 mm diametro. Hymenium 40–60 μm crassum, subhymenium 10–15 μm crassum, excipulum 20–40 μm crassum. Ascospores 8, 6,0–9,5 \times 4,5–5,5 μm . Pycnidia globosa, 100–200 μm diametro, pycnidiosporae 5–8 μm longae.

Cortex superior K non reagens (acidum usnicum continens), medulla alba K non reagens, C dilute rosea (acidum gyrophoricum continens).

Typus: CAPE—3322 (Oudtshoorn): 18 km N of De Rust, Meiringspoort (-BC), *F. Brusse* 772 14–1–17 (PRE, holotype).

This species is at present known only from the type collection, but is important in that it is a further member of the *X. hypoleia* group containing another orcinol p-depside, gyrophoric acid. Chemical relationships within this group will be discussed in a subsequent publication.

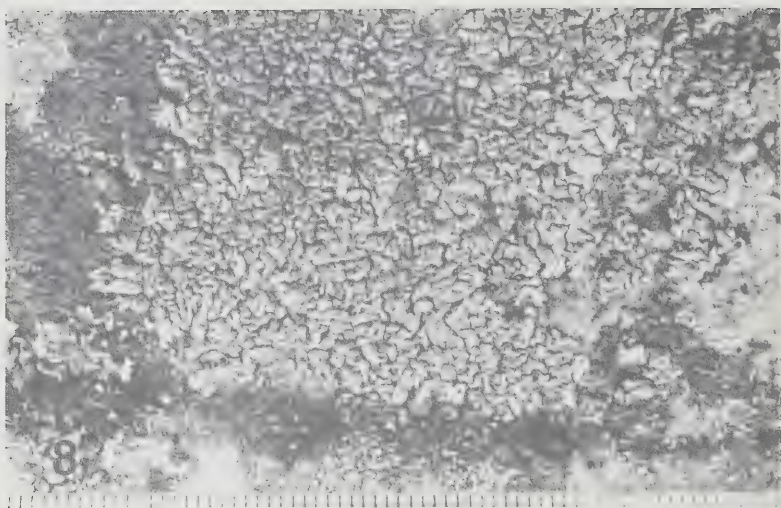


FIG. 8.
Xanthoparmelia ianthina Brusse (holotype).

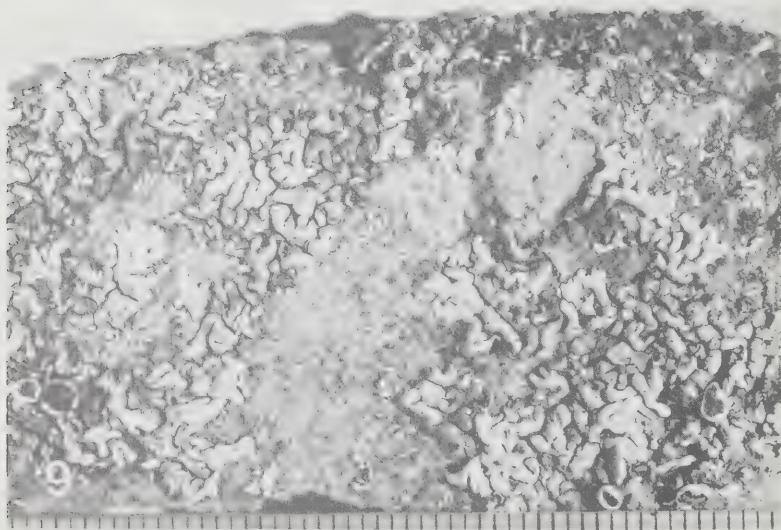


FIG. 9.
Xanthoparmelia karoo Knox et Brusse (holotype). Scales in mm.

***Xanthoparmelia walteri* Knox, sp. nov. Fig. 11.**

Thallus foliosus, flavovirens, prostratus vel subascendens, usque ad 30 mm diametro, saxa parva habitans. Lobi ligulati, maculatuli, 0,5–1,5 mm lati, paginis inferibus nigris, rugosis, nudis vel sparse rhizinatis. Isidiis sore-diisque carens. Cortex superior 18–20 μm crassus, stratum gonidiale 30–35 μm crassum, medulla 90–110 μm crassa, cortex inferior 12–15 μm crassus. Apothecia non visa.

Cortex superior K non reagens (acidum usnicum continens), medulla alba K flavescens tum sanguinea (acidum salazinicum et acidum norsticticum minutissimum continens).

Typus: S.W.A./NAMIBIA—2214 (Swakopmund): Namibwüste 10 bis 20 km nördlich von Swakopmund (-DA), Kieswüste auf dunklen Doleritsteinchen, Mitte Oktober 1977 + December 1977, L. Moisel für H. and E. Walter No. 5168.

Salazinic acid is certainly the most common medullary constituent in *Xanthoparmelia*, there being more than 50 valid species containing this substance. *Xanthoparmelia walteri*, lacking isidia and soredia, is clearly related to *X. constrictans* (Nyl.) Hale, but differs in its semi-erect growth form and in its more regular, straplike lobes.

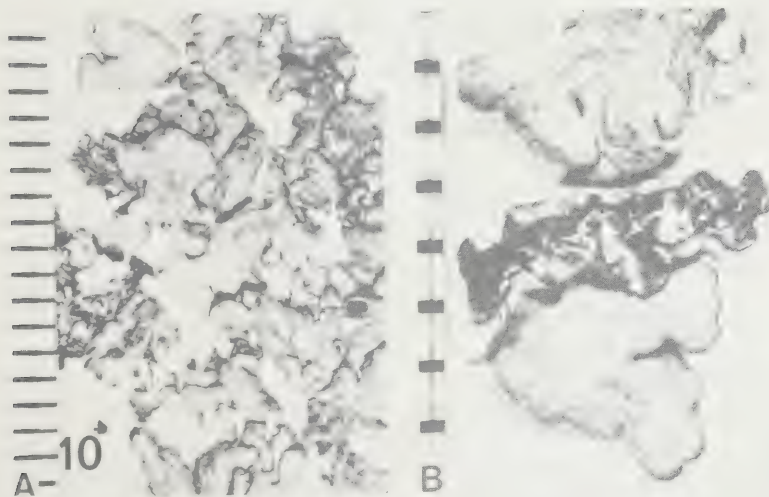


FIG. 10.

Xanthoparmelia leucostigma Brusse (holotype). Scales in mm.

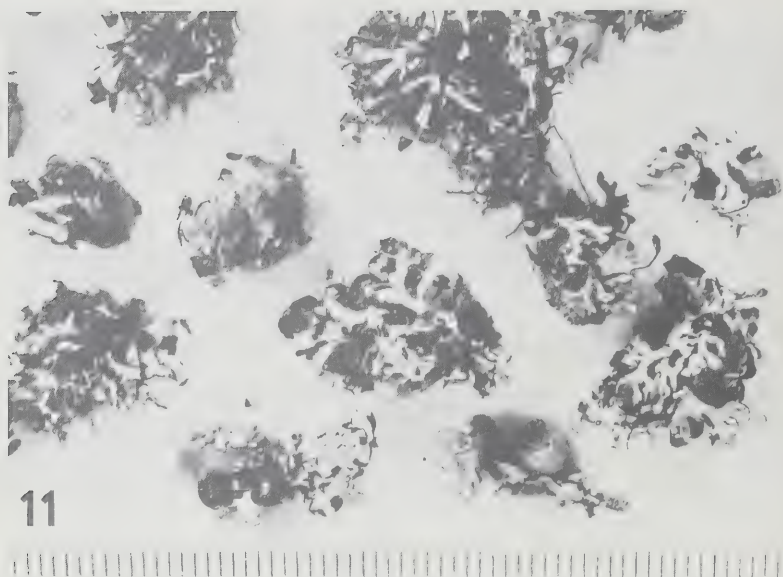


FIG. 11.
Xanthoparmelia walteri KNOX (holotype). Scale in mm.

ACKNOWLEDGEMENTS

The authors are grateful to the University of the Witwatersrand for financial support during the completion of the degree of M.Sc. by one of them (F.A.B.), and to the Council for Scientific and Industrial Research and the above University for financial support during a period of overseas study leave for the other (M.D.E.K.).

Thanks are also due to Dr. Mason E. Hale, Jr., of the Smithsonian Institution, Washington, D.C. for guidance during this work.

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AN ANNOTATED SYSTEMATIC CHECKLIST OF THE ANGIOSPERMAE OF THE CAPE RECEIFE NATURE RESERVE, PORT ELIZABETH

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ABSTRACT

The vegetation of the Cape Receife Nature Reserve, Port Elizabeth is discussed briefly. The 173 species recorded are listed in a systematic checklist. Of the 60 families recorded, the Asteraceae (Compositae) is the one best represented by far.

UITTREKSEL

'N GEANNOTEEERDE SISTEMATIESE KONTROLELYS VAN DIE ANGIO-
SPERMAE VAN DIE KAAP RECEIFE-NATUURRESERVAAT, PORT ELI-
ZABETH

Die plantegroei van die Kaap Receife-Natuurreservaat, Port Elizabeth, word kortliks bespreek. Die 173 spesies wat aangeteken is, word in 'n sistematiese kontrolelyns weergegee. Van die 60 families wat aangeteken is, is die Asteraceae (Compositae) op verre na die beste verteenwoordig.

INTRODUCTION

The Cape Receife Nature Reserve (S 34° 01', E 25° 42') is a small reserve, 366 ha in extent and situated 9.6 kilometres from the centre of the city of Port Elizabeth. It has approximately six kilometres of coastline and on the landward side it is bounded by the campus of the University of Port Elizabeth and the South African Defence Force rifle range.

The terrain is undulating, the highest point in the area, Receife Hillock, being 45 metres above sea level. Running in an east-west direction and separating the peninsula from the mainland is a broad belt of dune sand. In the eastern half of this belt a sewage treatment plant, with settling ponds, is well established. It is also in this half that an area of shifting sand has been stabilized successfully, a grass and shrub mixture having been used for this purpose. A few natural freshwater ponds also occur in the area.

Three roads traverse the area giving access to the lighthouse, the sewage works and the car park at the western side of the reserve.

The area was proclaimed a nature reserve in 1973 and is administered by

the Parks and Recreation Department of the City Council of Port Elizabeth. Entry is by permit only.

The survey was carried out because a reasonable knowledge of species occurring in a protected area is essential and very little floristic data were available.

METHODS

During 1981 the area was visited at regular intervals, but also at odd times prior to this. Specimens were collected in duplicate. The first set is housed in the herbarium of the University of Port Elizabeth and the second set was sent to the Botanical Research Unit, Grahamstown, where it was used by the author and the staff of the unit for identification purposes.

Plant communities were assessed visually. Flowering periods were recorded as well as presence or absence of species in the different communities. Abundance was estimated on a five-point scale: rare, uncommon, fairly common, common and very common.

RESULTS AND DISCUSSION

Vegetation

Acocks (1975) considers the area to be a coastal tropical forest type. He classifies it as Alexandria Forest (Veld Type 2) but does not discuss this relationship in the text and only shows it on the map.

During the present survey six communities were distinguished (Fig. 1).

1. Pioneer communities on unstabilized dunes, more or less concentrated along the eastern coastline.

The most important pioneers are *Arctotheca populifolia* and *Scaevola thunbergii*.

2. Rocky shore communities which occur on consolidated areas between the rocky shore and dune scrub, along the southern and south-western coastline.

The most important species occurring here are: *Chenolea diffusa*, *Cotula* species, *Gazania rigens* (both varieties), *Limonium linifolium*, *Sporobolus virginicus* and *Tetragonia decumbens*.

3. Dune scrub. This community occupies the largest area by far in the reserve. It is virtually impenetrable and collecting was limited to roadsides and an area that was destroyed by fire during February 1978.

The dominant species are: *Cassine* species, *Olea exasperata*, *Pterocelas-trus tricuspidatus*, *Rhus* species and *Sideroxylon inerme*.

4. Fynbos. Although it is not impossible that several fynbos patches are to be found within the dune scrub, only one of limited extent was easily accessible and investigated.

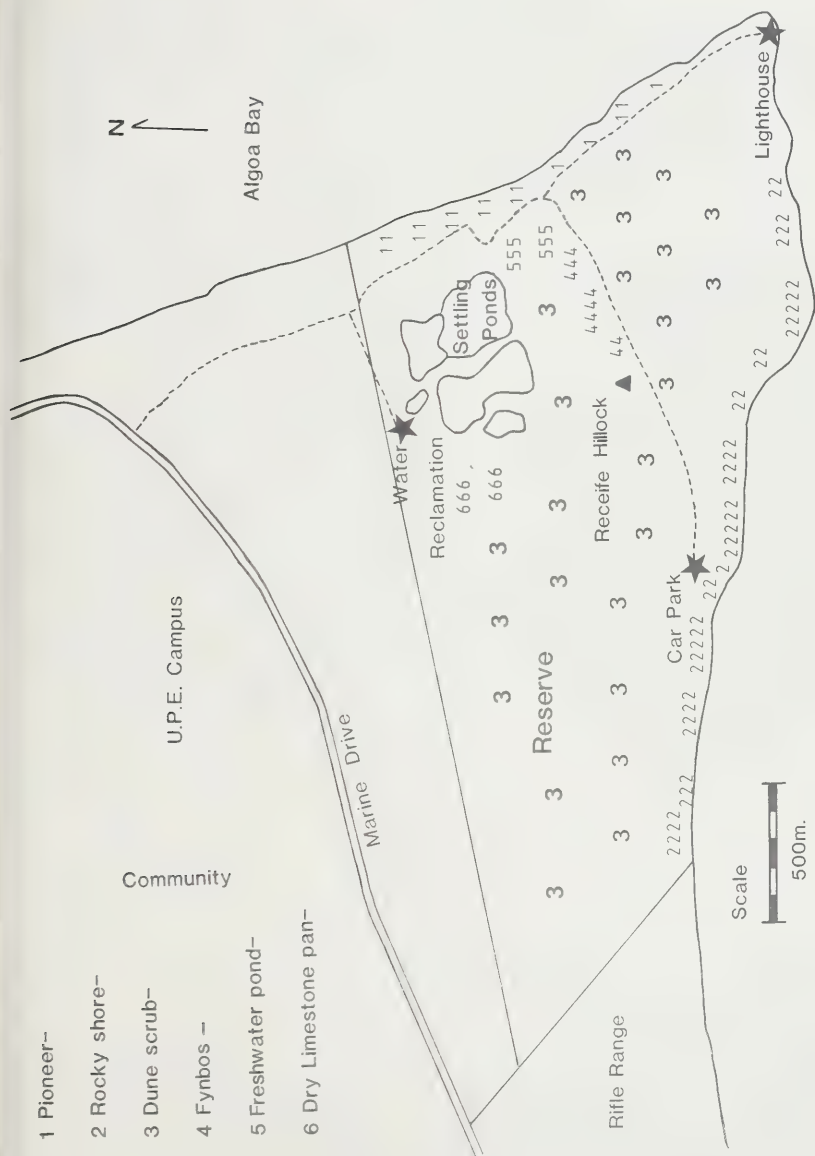


FIG. 1.

Combined Locality and Vegetation Map of the Cape Receife Nature Reserve, Port Elizabeth.

The commonest species occurring here are: *Agathosma apiculata*, *Muraltia squarrosa*, *Myrica quercifolia*, *Passerina vulgaris* and *Sutera microphylla*.

5. Freshwater pond community. A few natural freshwater ponds are to be found in the area.

Typha latifolia subsp. *capensis* is the dominant species.

6. Dry limestone pan community situated near the settling ponds.

The most important species are: *Chondropetalum microcarpum* and *Myrica cordifolia*.

Nothing comparable to dune forest occurs in the reserve.

Dense stands of *Acacia cylops*, especially in the northern and eastern parts of the reserve, are a serious threat to the indigenous vegetation.

Flora

During the survey, 60 families, 127 genera and 173 species of angiosperms were listed. An analysis of the families indicates that 11 (18,33 %)

TABLE 1.

Synopsis of the families whose species comprise more than 2 % of the total number listed in order of numerical importance together with the number of genera.

Family	No. of species	No. of species expressed as a % of total	No. of genera	No. of genera expressed as a % of total
Asteraceae (Compositae) ..	28	16,18	15	11,81
Poaceae (Gramineae)	11	6,36	10	7,87
Liliaceae	10	5,78	8	6,30
Cyperaceae	9	5,20	4	3,15
Fabaceae (Leguminosae) ..	9	5,20	6	4,72
Celastraceae	8	4,62	4	3,15
Mesembryanthemaceae . . .	6	3,47	6	4,72
Chenopodiaceae	5	2,89	4	3,15
Crassulaceae	4	2,31	2	1,57
Iridaceae	4	2,31	2	1,57
Santalaceae	4	2,31	4	3,15

are monocotyledons, and 49 (81,67 %) dicotyledons. The first is represented by 43 (24,86 %) species and the latter by 130 (75,14 %) species. There are 11 (18,33 %) families whose species contribute more than 2 % of the total number of species and these are listed in order of numerical importance in Table 1. Twenty nine (48,33 %) families are represented by one species, 14 (23,33 %) by two species and six (10,00 %) by three species.

Phenology

Flowering periods for 164 species were recorded. An analysis of these indicates a remarkable ascending fluctuation with two major peaks in September and November (Fig. 2).

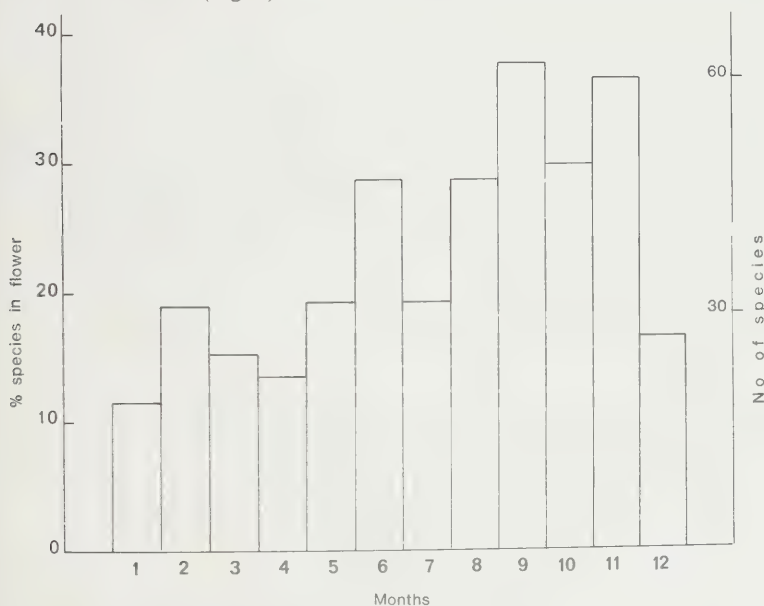


FIG. 2.

Histogram showing the relationship between the species flowering and the months of the year.

SYSTEMATIC LIST

The systematic list is arranged according to Dyer (1975, 1976), with the exception of *Viscum* which is classified according to Wiens and Tölken (1979). The numbers refer to the author's collecting number; fl. = flowering period; 1-12 = months of the year.

MONOCOTYLEDONAE

TYPHACEAE

Typha latifolia L. subsp. *capensis* Rohrb. 1944, fl. 11, freshwater ponds, common.

JUNCAGINACEAE

Triglochin striata Ruiz & Pav. 2400, fl. 11, seepage of freshwater ponds, fairly common.

POACEAE (Gramineae)

Cymbopogon marginatus (Steud.) Stapf ex Burt Davy 2377, fl. 9–11, dune scrub, burnt area, uncommon.

Stenotaphrum secundatum (Walt.) Kuntze 3030, fl. 12, rocky shore community, fairly common.

Ehrharta calycina J. E. Sm. 2983, fl. 9–11, dune scrub, burnt area, uncommon.

E. villosa Schult. f. 1887, fl. 9–11, pioneer dune communities, fairly common.

Pentstschis heptomera (Nees) Stapf 2403, fl. 9–11, pioneer dune communities, uncommon.

Lagurus ovatus L. 1932, fl. 9–11, dune scrub, disturbed areas, fairly common.

Sporobolus virginicus (L.) Kunth 2742, fl. 12–1, rocky shore communities, fairly common.

Cynodon dactylon (L.) Pers. 3033, fl. 12, rocky shore community, uncommon.

Lolium multiflorum Lam. 3006, fl. 10–11, dune scrub, disturbed areas, common.

Agropyron distichum (Thunb.) Beauv. 2741, fl. 11–1, pioneer dune communities, common.

Setaria sp. 2398, fl. 11, dune scrub, disturbed areas, uncommon.

CYPERACEAE

Juncellus laevigatus C.B.Cl. 3013, fl. 12, damp area beyond freshwater pond, locally fairly common.

Ficinia cf. *F. aphylla* Nees 2782, fl. 2, dry limestone pans, fairly common.

F. bulbosa Nees 2380, fl. 11, dune scrub, burnt area, common.

F. dunensis Levyns 2925, fl. 6, fynbos, uncommon.

F. cf. *F. ramosissima* Kunth 1872, fl. 9, dry limestone pans, fairly common.

F. truncata Schrad. 2273, fl. 8, dune scrub, burnt area, common.

Fuirena cf. *F. hirsuta* (Berg.) P. L. Forbes 3014, fl. 12, damp area beyond freshwater pond, locally fairly common.

Scirpus nodosus Rottb. 1937, fl. 11, pioneer dune communities near entrance to reserve, fairly common.

S. thunbergianus (Nees) Levyns 3015, fl. 12, damp area beyond freshwater pond, locally fairly common.

ARACEAE

Zantedeschia aethiopica (L.) Spreng. 2763, fl. 6–2, freshwater ponds, fairly common.

RESTIONACEAE

Chondropetalum microcarpum Pillans 1869, 2783, fl. 2, 9, dry limestone pans, common.

JUNCACEAE

Juncus kraussii Hochst. 3037, fl. 11–12, pioneer dune communities near entrance gate, common.

LILIACEAE

Androcymbium longipes Bak. 1849, fl. 9, dune scrub, fairly common.

Bulbine caulescens L. 1946, fl. 11, dune scrub, fairly common.

Trachyandra ovatum Kies 2986, fl. 8–9, dune scrub, fairly common, wide strapshaped leaves.

T. revolutum L. 2984, fl. 8–9, dune scrub, fairly common, narrow strapshaped leaves.

Aloe africana Mill. 2950, fl. 5–6, scattered in dune scrub.

Gasteria croucheri Bak. 2366, fl. 11, scattered in dune scrub.

Albuca sp. 2382, fl. 10–11, dune scrub, uncommon.

Massonia echinata L.f. 2959, 2985, fl. 6–7, dune scrub, burnt area, fairly common.

Asparagus asparagoides (L.) Wight 2930, fl. 6, dune scrub, fairly common.

A. racemosus Willd. 3032, fl. not recorded, dune scrub, fairly common.

AMARYLLIDACEAE

Boophane disticha Herb. 2780, fl. 1–2, dune scrub, burnt area, fairly common.

IRIDACEAE

Chasmanthe aethiopica (L.) N.E.Br. 2828, fl. 5–6, dune scrub, common.

Gladiolus floribundus Jacq. subsp. *floribundus* 3007, fl. 10, dune scrub, fairly common.

G. floribundus Jacq. subsp. *milleri* (Ker) Oberm. 2381, fl. 11, very abundant in burnt area.

G. guernzii Klatt 2390, fl. 11, pioneer dune community, uncommon.

ORCHIDACEAE

Holothrix exilis Lindl. 2373, fl. 11, fynbos, south-facing area, rare.

Bonatea speciosa (L.f.) Willd. 2368, fl. 11, dune scrub, uncommon.

Satyrium princeps Bol. 2987, fl. 9, stabilised dunes near car park, uncommon.

DICOTYLEDONAE

MYRICACEAE

Myrica cordifolia L. 2785, fl. 9, dry limestone pan, fairly common.

M. quercifolia L. 2497, fl. 8–9, fynbos, common.

VISCACEAE

Viscum obscurum Thunb. 2948, fl. 6, dune scrub, uncommon.

SANTALACEAE

Rhoiacarpus capensis (Harv.) A.DC. 1868, fl. 1–12, dune scrub, common.

Colpoon compressum Berg. 2797, fl. 1–12, dune scrub, fairly common.

Thesidium exocarpaeoides Sond. 2786, 2973, fl. 2, 8, fynbos, fairly common.

Thesium sp. 2764, fl. 2, rocky shore community, fairly common.

CHENOPODIACEAE

Chenopodium cf. *C. album* L. 2799, fl. 3, rocky shore community, uncommon.

C. murale L. 2829, fl. 5, disturbed area along road, common.

Exomis microphylla (Thunb.) Aell. var. *axyrioides* (Fenzl) Aell. 1866, fl. 9, dune scrub, uncommon.

Chenolea diffusa Thunb. 3031, fl. not recorded, rocky shore community, common.

Sarcocornia perennis (Miller) A. J. Scott 3029, fl. 12, rocky shore community, uncommon.

AIZOACEAE

Aizoon rigidum L.f. 2927, fl. 6, fynbos, uncommon.

Tetragonia decumbens Mill. 2923, fl. 6–9, rocky shore community, common.

T. fruticosa L. 2992, fl. 9, pioneer dune communities, common.

MESEMBRYANTHEMACEAE

Carpobrotus deliciosus (L. Bol.) L. Bol. 2963, fl. 8–9, dune scrub, fairly common.

Delosperma littorale (Kensit) L. Bol. 2964, fl. 8, fynbos, fairly common.

Disphyma crassifolia (L.) L. Bol. 3028, fl. 8–2, rocky shore community, common.

Drosanthemum intermedium L. Bol. 2965, fl. 8, fynbos, fairly common.

Mesembryanthemum aitonis Jacq. 2831, fl. 5, disturbed area in dune scrub, fairly common.

Nycteranthus plenifolius (N.E. Br.) Schwant. 2363, fl. 11, dune scrub, burnt area, common.

CARYOPHYLLACEAE

Silene bellidioides Sond. 2979, fl. 9, rocky shore community, common.

S. primulaeflora Eckl. & Zeyh. 2370, fl. 1–12, pioneer dune communities, common.

LAURACEAE

Cassytha cf. *C. filiformis* L. 2778, fl. 2, dune scrub, fairly common.

BRASSICACEAE (Cruciferae)

Heliophila linearis (Thunb.) DC. var. *linearis* 1890, fl. 10, dune scrub, uncommon.

CRASSULACEAE

- Cotyledon orbiculata* L. 2803, fl. 11–3, dune scrub, fairly common.
Crassula cotyledonis Thunb. 2364, fl. 11, dune scrub, common.
C. expansa Dryand. subsp. *filicaulis* (Haw.) Toelk. 2387, fl. 10–11, dune scrub, common.
C. sp. 2388, fl. 11, dune scrub, uncommon.

FABACEAE (Leguminosae)

- Aspalathus lactea* Thunb. subsp. *adelphea* (Eckl. & Zeyh.) Dahlg. 3018, fl. 11–2, fynbos, carpark turnoff, rare.
Crotalaria capensis Jacq. 1861, fl. 9, dune scrub on Receife Hillock, rare.
Indigofera heterophylla Thunb. 2924, fl. 6, fynbos, fairly common.
I. incana Thunb. var. *angustistipulata* Bak. f. 2970, 2989, fl. 8, fynbos and dune scrub, burnt area, fairly common.
I. striata L. 815, fl. 9, fynbos, uncommon.
I. sulcata DC. 2939, fl. 6, fynbos, common.
Psoralea bracteata L. 1935, fl. 11, fynbos, common.
Lessertia stenoloba E. Mey. 1938, 2375, fl. 9, fynbos and dune scrub, burnt area, fairly common.
Rhynchosia caribaea (Jacq.) DC. var. *picta* (E. Mey.) Bak. f. 2275, fl. 8, dune scrub, burnt area, uncommon.

GERANIACEAE

- Pelargonium capitatum* (L.) Ait. 2996, fl. 9–11, rocky shore community, common.
P. urbanum (Eckl. & Zeyh.) Harv. 2378, fl. 5–11, dune scrub, burnt area, common.

OXALIDACEAE

- Oxalis punctata* L.f. 2818, fl. 4, rocky shore community, uncommon.

LINACEAE

- Linum africanum* L. 3002, fl. 10–11, fynbos, next to road at carpark turnoff, localised.

ZYGOPHYLLACEAE

- Zygophyllum uitenhagense* Sond. 2816, fl. 1–12, disturbed areas, common.

RUTACEAE

- Agathosma apiculata* G. Meyer 2968, fl. 8–9, fynbos, common.
Coleonema pulchrum Hook. 2929, fl. 5–6, fynbos, fairly common.

POLYGALACEAE

Polygala ericaefolia DC. 3008, fl. 10, fynbos, uncommon.

Muraltia squarrosa (L.f.) DC. 2958, fl. 4–11, fynbos, common.

Nylandtia spinosa (L.) Dumort. 2931, fl. 6, dune scrub, uncommon.

ANACARDIACEAE

Rhus crenata Thunb. 2810, fl. 4, dune scrub, fairly common.

R. glauca Thunb. 1852, fl. 6, dune scrub, fairly common.

R. schlechteri Diels 2389, fl. 9, dune scrub, common.

CELASTRACEAE

Maytenus procumbens (L.f.) Loes. 2812, fl. 2–6, dune scrub, fairly common.

Putterlickia pyracantha (L.) Szyszyl. 3019, fl. 11, dune scrub, fairly common.

Pterocelastrus tricuspidatus (Lam.) Sond. 2945, fl. 11, dune scrub, common.

Cassine aethiopica Thunb. 3021, fl. 4–11, dune scrub, fairly common.

C. eucleiformis (Eckl. & Zeyh.) Kuntze 2278, fl. 8, dune scrub, common.

C. peragua L. 2951, fl. 6, dune scrub, fairly common.

C. reticulata (Eckl. & Zeyh.) Codd 1873, fl. not recorded, dune scrub, uncommon.

C. tetragona (L.f.) Loes. 2775, fl. 2, dune scrub, fairly common.

RHAMNACEAE

Phyllica ericoides L. 2792, fl. 3, fynbos, fairly common.

VITACEAE

Rhoicissus tridentata (L.f.) Wild & Drumm. 2798, fl. 3, dune scrub, fairly common.

MALVACEAE

Abutilon sonneratianum (Cav.) Sweet 1876, fl. 9, dune scrub, uncommon.

Lavatera arborea L. 1860, fl. 9, weed next to road at carpark turnoff, only a few plants.

STERCULIACEAE

Hermannia althaeoides Link. 2530, fl. 8, fynbos, uncommon.

H. filifolia L.f. 2952, fl. 6, fynbos, uncommon.

FLACOURTIACEAE

Dovyalis rotundifolia (Thunb.) Harv. 3022, fl. not recorded, Receife Hillock, rare.

THYMELAEACEAE

Passerina rigida Wikstr. 1893, fl. 10, pioneer dune communities, fairly common.

P. vulgaris (Meisn.) Thoday 2988, fl. 9, fynbos, fairly common.

ONAGRACEAE

Oenothera drummondii Hook. 2977, fl. 9, next to roadside near entrance, common.

ARALIACEAE

Cussonia thyrsiflora Thunb. 2770, fl. 2, dune scrub, fairly common.

APIACEAE (Umbelliferae)

Heteroptelis suffruticosa (Berg.) Leute 822, fl. 1-12, edge of dune scrub, near gate to lighthouse, uncommon.

ERICACEAE

Erica chloroloma Lindl. 2809, fl. 4-11, fynbos, fairly common.

E. cf. E. glumaeiflora Klotzsch ex Benth. 2936, fl. 6-8, fynbos, fairly common.

MYRSINACEAE

Rapanea gilliana (Sond.) Mez. 2940, fl. 6-8, dune scrub, fairly common.

PRIMULACEAE

Samolus porosus (L.f.) Thunb. 2765, fl. 2, swampy area in north-eastern part of reserve, uncommon.

PLUMBAGINACEAE

Limonium linifolium (L.f.) Kuntze 3035, fl. 3-11, rocky shore community, fairly common.

SAPOTACEAE

Sideroxylon inerme L. 2772, fl. 11-12, dune scrub, common.

EBENACEAE

Euclea natalensis A. DC. 2949, fl. 6, dune scrub, fairly common.

E. racemosa Murr. subsp. *bernardii* F. White 1853, fl. not recorded, dune scrub, fairly common.

OLEACEAE

Olea exasperata Jacq. 2941, fl. 6-11, dune scrub, common.

SALVADORACEAE

Azima tetraacantha Lam. 2947, fl. not recorded, dune scrub, Receife Hillock, uncommon.

GENTIANACEAE

Chironia baccifera L. 3016, fl. 11–12, fynbos, common.

C. decumbens Levyns 3036, fl. 12–3, dry limestone pan, uncommon.

C. tetragona L.f. 2495, fl. 2–3, dry limestone pan, uncommon.

APOCYNACEAE

Carissa bispinosa (L.) Desf. ex Brenan 2982, fl. 9, dune scrub, fairly common.

ASCLEPIADACEAE

Astephanus marginatus Decne 2830, fl. 5–11, dune scrub, common.

Secamone alpinii Schult. 1892, fl. 10–11, dune scrub, common.

CONVOLVULACEAE

Ipomoea cairica (L.) Sweet 2819, fl. 1–12, near freshwater ponds, common.

LAMIACEAE (Labiatae)

Leonotis dubia E. Mey. 2372, fl. 6–11, dune scrub on Receife Hillock, uncommon.

Salvia africana-lutea L. 2993, fl. 9–10, dune scrub, uncommon.

SOLANACEAE

Lycium tetrandrum Thunb. 2796, fl. 3–10, rocky shore community, fairly common.

Solanum quadrangulare Thunb. 2791, fl. 3–9, dune scrub, common.

SCROPHULARIACEAE

Sutera campanulata (Benth.) Kuntze 2794, fl. 3–8, dune scrub, burnt area, common.

S. microphylla (L.f.) Hiern 2820, fl. 4–11, fynbos, common.

Zaluzianskya capensis Walp. 2953, fl. 6–11, dune scrub, burnt area, fairly common.

SELAGINACEAE

Hebenstreitia cordata L. 1947, fl. 11, near entrance to reserve, uncommon.

PLANTAGINACEAE

*Plantago carnos*a Lam. 2385, fl. 11, rocky shore community, common.

RUBIACEAE

Anthospermum aethiopicum L. 2971, fl. 8, fynbos, fairly common.

*Hydrophylax carnos*a Sond. 1885, fl. 10, found on one dune only, west of light-house.

CUCURBITACEAE

Zehneria scabra (L.f.) Sond. 3012, fl. 10, dune scrub, uncommon.

Kedrostis nana (Lam.) Cogn. var. *nana* 2771, fl. 9–11, dune scrub, fairly common.

GOODENIACEAE

Scaevola thunbergii Eckl. & Zeyh. 3023, fl. 11–2, pioneer dune communities, common.

ASTERACEAE (Compositae)

Felicia echinata (Thunb.) Nees 2832, fl. 5–9, fynbos, uncommon.

F. erigeroides DC. 2928, fl. 5–6, dune scrub, uncommon.

Conyza pinnatifida Less. 2766, fl. 2, swampy area in north-eastern part of reserve, uncommon.

C. scabrida DC. (= *C. ivifolia* (L.) Less.) 2767, fl. 2, swampy area in north-eastern part of reserve.

Tarchonanthus camphoratus L. 2793, fl. 2–4, dune scrub, uncommon.

Helichrysum cymosum (L.) D. Don 2801, fl. 2–3, swampy area in north-eastern part of reserve.

H. sordescens DC. 1845, fl. 9, dune scrub, common.

H. teretifolium (L.) D. Don 1844, fl. 9–10, dune scrub, common.

Stoebe cinerea (L.) Thunb. 1870, fl. 9, near settling ponds, uncommon.

Metalasia muricata (L.) D. Don 1305, fl. 5–6, widespread, fairly common.

Cotula coronopifolia L. 2955, fl. 6–11, seepage area near freshwater ponds, uncommon.

C.sp.(= *Cenia pectinata* (Eckl.) DC.) 2967, fl. 8–11, rocky shore communities and dune scrub in open spaces, common.

C.sp.(= *Cenia sericea* DC.) 2921, fl. 6–8, rocky shore communities and dune scrub in open spaces, common.

Pentzia globifera (Thunb.) Hutch. 2402, fl. 11, disturbed area in dune scrub, common.

Senecio elegans L. var. *diffusus* Harv. 2975, fl. 9–10, pioneer dune community, fairly common.

S. ilicifolius Thunb. 3009, fl. 10, disturbed area in dune scrub, common.

S. inaequidens DC. 2833, fl. 5–10, disturbed area in dune scrub, common.

S. lanceus Ait. 2768, fl. 2, swampy area in north-eastern part of reserve, uncommon.

S. oederiaefolia DC. 2978, fl. 9–10, rocky shore community, common.

Othonna amplexicaulis Thunb. 2956, fl. 4–9, dune scrub, common.

Osteospermum fruticosum (L.) T. Norl. 2974, fl. 8–9, rocky shore community, fairly common.

Chrysanthemoides monilifera (L.) T. Norl. 1302, fl. 1–12, widespread.

Ursinia chrysanthemoides Harv. 2990, fl. 8–11, dune scrub, burnt area, common.

Arctotheca calendula (L.) Levyns 2836, fl. 5, disturbed area along road to light-house, common.

A. populifolia (Berg.) T. Norl. 1299, fl. 1–12, pioneer dune communities, common.

Gazania linearis (Thunb.) Druce 3034, fl. 8–2, fynbos, fairly common.

G. rigens (L.) Gaertn. var. *leucolana* (DC.) Roessl. 2485, fl. 1–12, rocky shore community, common, leaves hairy on both surfaces.

G. rigens (L.) Gaertn. var. *uniflora* (L.f.) Roessl. 2815, fl. 1–12, rocky shore community, common, leaves hairy on lower surface.

ACKNOWLEDGEMENTS

I wish to thank the City Council of Port Elizabeth for permission to undertake this survey; the staff of the Albany Museum Herbarium, Botanical Research Unit, Grahamstown for assisting with identification; Mr. Adrien Odgers for useful information and for accompanying me into the reserve on most of my visits; Ms Felicity Kapp and Ms Anita Tait for technical assistance.

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SHORT NOTE

**ALOE MEYERI VAN JAARVELD, AND A. RICHTERSVELDENSIS
VENTER & BEUKES**

P. VORSTER

(Department of Botany, University of Stellenbosch, Stellenbosch 7600,
R.S.A.)

Aloe richtersveldensis Venter & Beukes was published in Kew Bull. **36**: 675 (-678) on 11.6.1982, having been accepted for publication in February 1981. However, what is obviously the same species, had been described under the name *Aloe meyeri* van Jaarsveld in Jl S. Afr. Bot. **47**: 567 (-571) on 1.7.1981, having been accepted for publication on 5.3.1981.

Following Article 11 of the I.C.B.N. (1978 ed.), the correct name for this species therefore is *Aloe meyeri*, and *A. richtersveldensis* is here reduced to a synonym of *A. meyeri*.

Venter & Beukes' paper contains a map showing the distribution of *A. meyeri* and its closest allies, which constitutes an useful addition to van Jaarsveld's paper.

BOOK REVIEWS

THE BIOCHEMISTRY OF ALKALOIDS, by Trevor Robinson, with pp. viii + 225 and 35 figures. 2nd ed. New York, Heidelberg, Berlin: Springer-Verlag, 1981. Volume 3 in the series "Molecular Biology, Biochemistry and Biophysics". DM 88, approx. US\$ 41.00. ISBN 0-387-10795-9.

This book is one of the series, *Molecular Biology, Biochemistry and Biophysics*, edited by A. Kleinzeller, G. F. Springer and H. G. Wittmann. It will be of interest to plant biochemists, pharmacologists and natural product chemists.

The contents of this publication have been structured into three major sections. The first two chapters are introductory chapters which deal with the definition of alkaloids, their chemical classification based on their carbon-nitrogen skeletons, their distribution in nature, their taxonomic significance, the localisation of alkaloids within the plant, ontogenetic changes in the alkaloid content of the plant, the function of alkaloids in the plant and finally a summary of the general theories of alkaloid biosynthesis. The treatment of the major groups of alkaloids then follows with the emphasis on biosynthesis. In recent years one of the most exciting developments in the field of alkaloid biosynthesis has been the identification of some of the enzymes which regulate the formation of these compounds. This important body of work has been incorporated throughout these chapters. The final section deals firstly with the metabolism of alkaloids by animals, micro-organisms and higher plants and secondly with their pharmacologic and toxicologic effects.

The book, in hard cover and measuring 170 × 250 mm, is very well written and the quality of production is excellent. There are very few errors. The figures and tables are adequate although on a number of occasions names of alkaloids are mentioned in the text but no formulae are given. References for each chapter are grouped at the end of the chapter and the literature has been covered through to June 1980.

This book can be recommended for postgraduate students and for research workers.

W. E. CAMPBELL

BASIDIUM AND BASIDIOCARP: EVOLUTION, CYTOLOGY, FUNCTION AND DEVELOPMENT, edited by Kenneth Wells and Ellinor K. Wells, with pp. xi + 187 and 117 figures. New York, Heidelberg, Berlin: Springer-Verlag, 1982. DM 89, approx. US\$ 39.60. ISBN 3540-90631-2.

Another fine book in the *Springer Series in Microbiology* (Editor: Mortimer P. Starr) in which a comprehensive review is given of some recent studies on basidiomycetes. This major class of the Fungi is examined from multidisciplinary viewpoints—taxonomic, cytological, molecular biological, physiological and biochemical. A variety of experimental techniques are employed and special emphasis is placed on the basidium and the basidiocarp.

Oberwinkel stresses the importance of comparative morphological studies of the basidium and basidiospore as a means of understanding evolution within the Basidiomycotina. McLaughlin reviews the non-nuclear events during basidial and basidiospore ontogeny while Thielke examines recent studies of meiosis in the basidium, especially those dealing with the spindle apparatus and associated structures. Lu's studies of meiosis in the basidia of *Coprinus cinereus* have extended the information available on this process to the molecular level. Uno and Ishikawa describe a series of studies suggesting that adenosine 3'5'-cyclic monophosphate is an essential component in the initiation of basidiocarp formation in a form of *Coprinus macrorrhizus*. Gruen has brought together the results of his own extensive studies, and those of others on the influence of the pileus and somatic mycelium on stipe elongation during the rapid expansion stage. He also reviews and discusses the evidence that the somatic mycelium and/or nutrients enhance stipe elongation and that the numbers of hyphal segments increase during this phase. Completing the studies described by Gruen is the report by Gooday, who describes his efforts to determine which hyphal constituents control stipe elongation by analyzing chemically the major components before and after the major period of elongation.

In addition to the detailed reference list at the end of each chapter, an author index and a good subject index are provided. The book is pleasingly printed, has many good informative photomicrographs and can be recommended as reference for post-graduate courses in Mycology. Most mycologist will find something of value in this book.

ALBERT EICKER

BIOCHEMISTRY AND PHYSIOLOGY OF HERBICIDE ACTION, by C. Fedtke, with pp. xi + 202, 43 figures and 58 tables. Berlin, Heidelberg, New York: Springer-Verlag, 1982. DM 156, approx. US\$ 69.30. ISBN 3-540-11231-6.

Intensive research has been conducted into the properties and characteristics of modern herbicides. These substances are of great economic importance. In this book Dr. Fedtke clearly shows that they are of very considerable scientific importance as well, a fact that is not always adequately appreciated. The nature and scope of the book can best be described in this excerpt from the Foreword. "This book describes the effects of herbicides on the metabolism of higher plants from the viewpoint of the plant physiologist. The material of this book is therefore, as far as possible, divided into areas of metabolism. This book intends (1) to present the reader with current knowledge and views in the area of herbicide modes of action and (2) to promote the future use of herbicides as metabolic inhibitors in plant physiological research to the advantage of both, the pesticide and plant science".

The book is written in a clear, concise manner, with clear illustrations and tables. The structural formulae for the compounds discussed are given. The bibliography is excellent and very valuable.

Until this book appeared, it was difficult to find all this information in one place, although some of it was readily available. However, the fact that all this material is contained in the one volume makes this book so valuable for plant physiologists. They can readily integrate this material into their own studies and it is in an ideal form for study by advanced level students and postgraduates. All the colleagues to whom I showed this book were very impressed with it and felt it filled a serious gap on our shelves.

There is too much detailed information in this book to be able to discuss its contents in detail. But to get an impression of the systematic approach of the author, a look at the chapter headings is very useful. Due to lack of space the sub sections of the chapters cannot be given, but in Chapter C—Photosynthesis—there are eleven sub sections with titles like—Inhibition of Photosynthetic Electron Flow and Physiological Effects Induced by Herbicides that Inhibit Photosynthesis. There are also 436 references cited in this chapter, which is the longest in the book and takes up half the text.

Contents

- A. Approaches to and Definitions of Mechanisms of Herbicides
- B. Plant Metabolism—a Synopsis of Principles
- C. Photosynthesis
- D. Energy Conversion
- E. Nucleic Acid and Protein Synthesis
- F. Microtubules
- G. Lipid Metabolism
- H. Herbicidal Germination Inhibitors with Unknown Mode of Action
- I. Herbicides with Auxin Activity
- K. Auxin-Inhibitor Herbicides
- L. Aromatic Amino Acid Biosynthesis
- M. Other Herbicides and Mechanisms

The influence that herbicides had upon nitrogen metabolism was of considerable interest to the reviewer as was the matter relating to auxin activity. But the book is packed with valuable interesting information. Dr. Fedtke has succeeded in the first of his stated aims and his second one, to promote the use of herbicides as metabolic inhibitors in research, is sure to follow the reading of this book by experimentalists.

Highly recommended for plant physiologists, plant biochemists and other plant scientists as well as graduate or senior students.

K. H. SCHÜTTE

NUCLEIC ACIDS AND PROTEINS IN PLANTS 1: STRUCTURE, BIOCHEMISTRY AND PHYSIOLOGY OF PROTEINS, edited by D. Boulter and B. Parthier, with pp. xx + 768 and 135 figures. Berlin, Heidelberg, New York: Springer-Verlag, 1982. DM 268, approx. US\$ 119. ISBN 3-540-11008-9.

The vast volume of information accumulated on plant physiological processes as well as the rapid advances in the technology associated with this field of science over the last 15 years necessitated the publishing of a new series of *Encyclopedia of Plant Physiology*. That all libraries should have these books on their shelves is essential.

The present book, Volume 14A, covers a wide range of topics. These were reviewed by recognised experts in their fields. The editors succeeded in reducing overlap to a level which is essential for clarity and continuity in the text. The 17 chapters all contribute to a better understanding of the role of nucleic acids and proteins in plants. In order to achieve this understanding the Volume was divided into two sections. In the first, topics related to the biosynthesis and metabolism of protein amino acids and proteins were covered. Thus attention was given to ammonia assimilation and amino acid metabolism; transfer RNA and aminoacyl-tRNA synthetases in plants; ribosomes, polysomes and the translation process; post translational modifica-

tions; protein degradation; physiological aspects of protein turnover; structures of proteins; protein types and distribution; cereal storage proteins, structure and role in agriculture and food technology; biochemistry and physiology of leaf proteins; microtubule proteins and P-proteins; plant peptides; and immunology.

In the second section entitled "Nucleic acids and proteins in relation to specific plant physiological processes" attention was given to seed development; protein and nucleic acid synthesis during seed germination and early seedling growth; leaf senescence; and macromolecular aspects of cell wall differentiation.

Throughout this very neatly presented volume, in which the printing and figures are of the highest quality, the authors attempted to state what is currently known and how our knowledge has changed over the past two decades. In many cases they identified and indicated future areas of research. This should prove most useful for both lecturers and students working on proteins and in the general field of nitrogen metabolism. This thorough review of the literature ensures that this volume will serve as a reference book for many years to come both at the undergraduate and postgraduate levels.

J. VAN STADEN

CHROMOSOME NUMBERS IN SOME SOUTH AFRICAN SPECIES OF *LINUM* L. (LINACEAE)

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ABSTRACT

Chromosome numbers of five (of fourteen) species of section *Linopsis* of the genus *Linum* of South Africa were counted.

On gross morphological bases the South African species have been thought to be more or less intermediate between species of the Mediterranean region and those of the New World. They are characterized by base chromosome numbers of $x = 9$ (Old World) or $x = 18$ (New World) and it was thought that the chromosome number of the South African species would likely be one or the other. The South African species examined, however, prove to have a base chromosome number of $x = 15$ and some doubt is raised as to their exact position in the section.

UITTREKSEL

CHROMOSOOMGETALLE IN SOMMIGE SUID-AFRIKAANSE SOORTE VAN *LINUM* L. (LINACEAE)

Die chromosoomgetalle van vyf (uit veertien) soorte van die seksie *Linopsis* van die genus *Linum* van Suid-Afrika is bepaal.

Op 'n uiterlike morfologiese basis is gemeen dat die Suid-Afrikaanse soorte min of meer intermediêr tussen die soorte van die Middellandse See en dié van die Nuwe Wêreld is. Hulle word gekenmerk deur basiese chromosoomgetalle van $x = 9$ (Ou Wêreld) of $x = 18$ (Nuwe Wêreld) en is dit verwag dat die Suid-Afrikaanse soorte waarskynlik dieselfde as die een of ander sal wees. Die Suid-Afrikaanse soorte wat ondersoek is het egter 'n basiese chromosoomgetal van $x = 15$ en bestaan daar dus nou onsekerheid van hulle presiese plek in die seksie.

Key words: *Linum*, Linaceae, South Africa, flax, chromosome numbers.

INTRODUCTION

The author has been occupied with the classification of the section *Linopsis*, of the genus *Linum*, which includes many of the yellow-flowered species of both Old and New Worlds. Among other things, the chromosome numbers of many of the species, except those of South Africa, have become known.

The section ranges from southern Europe to eastern and southern Africa and to North and South America, with a single outlier in India and Sri Lan

Accepted for publication 25th November, 1982.

ka. The species of the Mediterranean are mostly diploid, with $n = 9$ or 10 . One small group, the subsection *Dichrolinum*, which includes *L. suffruticosum* L., *L. tenuifolium* L. and their allies, includes taxa with $n = 9$, 18 and 36 . The small subsection *Halolinum*, with *L. trigynum* L. and the heterostylous species *L. tenue* Desf. and *L. maritimum* L., is characterized by $n = 10$. They differ from others in the section in having linear stigmas and thus appear to be out of the main line of evolution in the section, other species of which have capitate stigmas. The latter thus far have all been found to have $x = 9$. Mediterranean species, such as *L. setaceum* Brot., and *L. strictum* L., for example, have $n = 9$, while *L. volkensii* Engl., of eastern Africa, is interpreted as a hexaploid with $n = 27$ (Lewis, 1964). In South America the eight species (of fourteen) thus far examined have been found to have $n = 18$ or 36 (Mildner and Rogers, 1978), while the base number for the numerous North American species of the section also proves to be $x = 18$ (Rogers, 1969).

The South African species are morphologically very similar to species of the New World and, therefore, they were expected to follow the same pattern and it would mainly be a matter of discovering whether they might still retain the primitive diploid number of $n = 9$ or the tetraploid number of $n = 18$ of the apparently closely allied New World species. Earlier reports (in Darlington and Wylie, 1955) of *L. africanum* having $n = 15$ or 16 were not given much credence, since seed of African-grown plants of *L. usitatissimum* L., the cultivated flax, which is said to have these chromosome numbers, is frequently distributed under the name "*L. africanum*".

MATERIAL AND METHODS

In the early part of 1982, the author had the opportunity to collect some material of several South African species, all from the Cape Province. They included *Linum acuticarpum*, *L. africanum*, *L. comptonii*, *L. gracile* and *L. heterostylum*. Flower buds were collected and preserved in Carnoy's fluid. Anthers were later squashed in acetocarmine and chromosomes of first or second meiotic division examined.

Voucher specimens are deposited in the herbarium of Wayne State University (WUD); duplicates are presently being prepared for distribution to the major herbaria of South Africa.

RESULTS

Chromosomes of all the species of section *Linopsis* examined thus far (approximately fifty species) have proved to be very small, averaging about 2μ in length at first metaphase of meiosis. Those of South African species

prove to be no exception and so no attempt has been made to discern details of chromosome structure and only numbers of chromosomes were determined. The following results were obtained:

Linum acuticarpum Rogers $n = 15$. Roadside, ca 1 km west of the bridge over the Palmiet R., along R 44, Caledon District. Rogers 13704, 19 Feb., 1982.

Linum africanum L. $n = 29$. Roadside, Heuningkloof, near Gordon's Bay, Somerset West District. Rogers 13683, 1 Feb., 1982.

Linum comptonii Rogers $n = 15$. Moist soil, Hangklip, Caledon District. Rogers 13693, 10 Feb., 1982.

Linum gracile Planch. $n = 15$. Half way up the south slope of Outeniquas Pass, north of George, George District. Rogers 13696, 13 Feb., 1982.

Linum heterostylum Rogers $n = 15$. (1) Geelrug on Rietfontein Private Nature Reserve, Bredasdorp District. Rogers 13684, 2 Feb., 1982. (2) Near De Hoop Provincial Farm, near Bredasdorp, Bredasdorp District. Rogers 13685, 3 Feb., 1982. (3) Slopes, 2–3 km from Barrydale toward Tradouw Pass, Swellendam District. Rogers 13694, 11 Feb., 1982.

DISCUSSION AND CONCLUSIONS

Clearly the South African species, at least insofar as chromosome counts have now been made (there are nine additional species which have not been examined), have a base number of $x = 15$ and are not direct intermediates between the Mediterranean and the New World species of the section. *Linum africanum* is a variable species, of which the plants examined are somewhat different from the Linnaean type. The chromosome number of the population sampled is almost certainly an aneuploid derivative of the number $n = 30$.

Very possibly *Linum mysurense* Heyne ex Benth., of India and Sri Lanka, is related most closely to South African species. It is rather distantly disjunct from any other species of the section, except for species such as *Linum strictum* L. and *L. trigynum* L., which in recent times have become widely adventive, and it has been distinguished from all other Old World species of the section in having a chromosome number of $n = 30$ (Rogers, 1975). Until the South African species were examined no other Old World species of the section were known which might be derived from a base number of $x = 15$.

Examination of additional species, especially *L. thunbergii* Eckl. & Zeyh. which links, geographically and morphologically, species of east Africa with those of South Africa, will very possibly throw some further light on the relationships of the latter to others on the continent as well as to those of the New World.

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GALIAM ROURKEI (RUBIACEAE): A NEW SPECIES FROM THE SOUTH WESTERN CAPE

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ABSTRACT

Galium rourkei, a new species from the south western Cape, is described. Its affinities to the two Cape endemic species *G. subvillosum* and *G. mucroniferum* are discussed, and the isolated position of this group among the southern African *Galium* species is pointed out.

UITTREKSEL

GALIAM ROURKEI (RUBIACEAE): 'N NUWE SOORT VANAF DIE SUID-WESTELIKE-KAAP

Galium rourkei, 'n nuwe soort vanaf die suidwestelike-Kaap, word beskryf. Dié soort se affiniteite met die twee Kaapse endemiese soorte *G. subvillosum* en *G. mucroniferum* word bespreek en die geïsoleerde posisie van dié groep tussen die endemiese soorte van *Galium* van suidelike Afrika word aangetoon.

Key words: *Galium*, sp. nov., Rubiaceae, south western Cape.

Dr. John Rourke has kindly drawn my attention to an apparently very rare and as yet undescribed *Galium* species from the Kogelberg Forest Reserve in the south western Cape.

Galium rourkei Puff, sp. nov. similis *G. subvillosi* Sond. sed cymis 2-floris et foliis stipulisque foliaceis minoribus 4-5-natim verticillatis differt; affinis *G. mucroniferi* Sond. sed foliis oblanceolatis vel spathulatis multo latioribus facile distinguenda.

Herba perennis, prostrata, ramosissima. *Caules* graciles, \pm quadrangulares, c. 100-200 mm longi. *Folia* et *stipulae* foliaceae 4-5-natim (rarissime 6-natim) verticillata, 5-7 mm longa, (2)2.5-5 mm lata, oblanceolata vel spathulata, pilosa, apicibus cuspidatis-mucronatis. *Cymae* 2-florae, pedunculi 1.5-5 mm longi, pedicelli 1.5-3 mm longi sub anthesi, postfloraliter usque ad 6 mm elongati, divaricati. *Corolla* cremeo-alba, rotata, (2.5)3-3.5(4) mm diam., lobi 4, \pm ovati. *Fructus* niger, pilis albis obtectus; mericarpium unum saepe abortum.

Accepted for publication 23rd December, 1982.

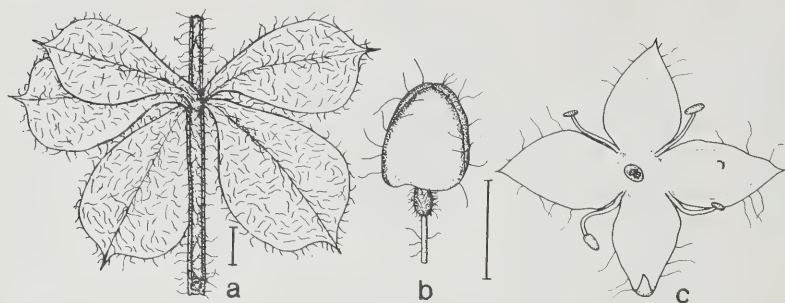


FIG. 1.

Galium rourkei. a, a node from the midstem region: 5 leaves in a whorl; b, bud; c, flower from above. Camera lucida drawings from the type collection; the bar represents 1 mm.

Type: South Africa, Cape Province—3418 (Simonstown): Kogelberg Forest Reserve, Kuduberg (-BD), c. 830 m, 17.12.1981, *Rourke 1765* (NBG, holo.; WU, iso).

Perennial. *Stems* \pm much-branched, delicate, \pm prostrate, c. 100–200 mm long and c. 0,5–1 mm in diam., \pm distinctly 4-angled, at least younger parts with curved or straight white hairs on the angles, c. 0,4–0,7 mm long. Longest internodes c. 8–12(17) mm. *Middle cauline leaves* (Fig. 1a) in whorls of 4–5(-6), 1-nerved, 5–7 \times (2)2,5–5 mm, oblanceolate to spatulate, with a distinct, rigid point at the apex, up to 1 mm long; with straight or curved hairs, c. 0,3–0,6 mm long on the upper and lower surface and margins; margins straight. *Synflorescences* much-reduced; partial inflorescences 2-flowered; peduncles 1,5–5 mm long, hairy; pedicels filiform, hairy, 1,5–3 mm at anthesis, to 6 mm and divaricate in fruit, only rarely subtended by lanceolate bracts, c. 1,5 \times 0,5 mm. *Flowers* (Fig. 1c) strongly protandrous, 4-merous; corolla (2,5)3–3,5(4) mm in diam., rotate, creamy-white; lobes \pm ovate, longer than wide, acute, with a few white, straight or curved hairs on the margins; stamens c. 1–1,5 mm long, filaments filiform, anthers brownish, \pm ellipsoidal; styles very short, 0,5 mm or less, stigma \pm capitate. *Buds* (Fig. 1b) \pm ovoidal. *Fruits* dry, blackish, covered with white spreading hairs, c. 0,3–0,5 mm long; mericarps \pm globose, each c. 1,5–2 mm in diam.; often only one mericarp developed.

Average pollen diameter: 27,63 μ m.

Habitat: In permanent shade under damp rock cliffs, in south-facing situation. Growing in association with mosses and *Hymenophyllum* (notes from the type collection).

Although only known from the type collection, I have no doubt that *G. rourkei* is a "good" new species. It is allied to both *G. subvillosum* and *G. mucroniferum*, primarily on account of the similar, reduced inflorescences (3- or 2-flowered partial inflorescences) and flowers with stamens (filaments) almost as long as the corolla lobes. Also similar habitat conditions (sheltered, cool, moist) and corresponding average pollen diameters, larger than those of other Cape species of *Galium* (except for *G. undulatum*, an unlikely ally which markedly differs in floral and inflorescence structure), suggest an affinity. The large average pollen diameter may, furthermore, indicate poly-(?tetra)ploidy, which has been documented for both *G. subvillosum* and *G. mucroniferum* (Puff, 1978).

G. rourkei differs from both species in having its leaves arranged in whorls of 4 or 5 (6 leaves per whorl are the exception), shorter and broader leaves (leaf size and shape of some forms of *G. subvillosum* may \pm overlap with those of *G. rourkei*, but the former has always 3- rather than 2-flowered partial inflorescences), much more delicate stems and usually shorter internodes.

It is noteworthy that this group of three Cape species seems quite isolated and does not appear to have any close allies in either the Cape or anywhere else in southern Africa, much in contrast to, for example, the *G. capense* group (*G. capense* and the allied Cape species *G. bredasdorpense*,¹ *G. monticulum* and *G. amatymbicum*). The latter is allied to *G. bussei* in south central and tropical east Africa, *G. ossirwaense*, to an as yet undescribed species from Ethiopia and, ultimately, to the *Galium verum* alliance in Europe and Asia. In an article dealing with the evolution of the African and Madagascan *Galium* species (in preparation), these two contrasting groups of *Galium* Cape species will be discussed in detail.

To accommodate *G. rourkei* in the key to the southern African species of *Galium* (Puff, 1978: 220), the beginning of the key needs to be altered as follows:

¹ When this species was described (Puff, 1978: 244), only the type specimen was known. In the meantime, the following additional collections have been brought to my attention:

CAPE—3420 (Bredasdorp): De Hoop near Tierhoek, (-AD), 30 m, *Burgers 2133* (STE), v. d. Merwe 2001 (STE); farm Windhoek, v. d. Merwe 2059 (STE); —, Fonteinkloof on W side of De Hoop vlei, 120 m, *Burgers 1251* (STE).

These collections, furthermore, confirm my original assumption that the species may be confined to limestone areas. The listed specimens were gathered in cracks and holes in limestone.

- 1. Leaves 3-nerved, strictly in whorls of 4 1. **G. thunbergianum**
 Leaves 1-nerved, in whorls of 4–10 1a
- 1A. Leaves in whorls of 4–5 (rarely 6), 5–7 × (2)2,5–5 mm, oblanceolate to
 spathulate 10A. **G. rourkei**
 Leaves in whorls of 6–10, much larger or, if small, ± ovate-lanceolate or linear-
 lanceolate 2
- 2. Synflorescences 2

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A NEW *EUPHORBIA* FROM SOUTH WEST AFRICA

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ABSTRACT

A new tuberous rooted dwarf *Euphorbia* with a very restricted distribution on the Namuskluft, near Rosh Pinah, just north of the Orange River, is described. Vegetatively indistinguishable from *E. wilmaniae* Marl., its floral and fruiting characteristics are entirely different.

UITTREKSEL

'N NUWE *EUPHORBIA* VANAF SUIDWES-AFRIKA

'n Nuwe dwerg *Euphorbia* met 'n wortelknol en met 'n baie beperkte verspreiding op die Namuskluft, naby Rosh Pinah, net noord van die Oranjerivier, word beskryf. Vegetatief nie te onderskei van *E. wilmaniae* Marl. nie, maar blom- en vrugkenmerke verskil heeltemal.

Key words: *Euphorbia*, sp. nov., Euphorbiaceae, South West Africa/Namibia, Gariep Centre.

Euphorbia namuskluftensis Leach, sp. nov. ad *E. wilmaniae* Marl. in characteribus vegetativis simillissima sed illa glandulis non prominenter rugosis sine processibus dactylinis; ovulo vix exserto seminibusque minoribus proportionem angustioribus statim distinguenda.

Planta dioecia, succulenta, inermis, ramosissima; ramis ramulisque aeriis confertis, raro in longitudinem 20 mm attingentibus; radice tuberosa rhizomatosa, solum in terra calcarea crescens. Rami ramulique tuberculati, estipulares micro-scabrelli, c. 5 mm crassi. Folia carnosa, ovata, acuta, leviter plicata, patulo-recurva, variabiliter micro-scabrella, decidua, cicatrice brunnea tuberculi ad apicem remanenti. Inflorescentia axillaris, ad apicem ramorum, plerumque cyathio solitario unisexuali in pedunculo bracteato portato. Bractee plus minusive oblongae, aliquanto obtusae, irregulariter denticulatae, plerumque apicula breviter plicata, acuta, recurva instructae, anguste subpellucido-marginatae, saepe in superficie sparsim pubescentes. Cyathium glabrum vel raro sparsissime micro-scabrellum, 2-3 mm longum, c. 3 mm diam.; glandulae 5, erectae, aliquanto cuneatae, 1-2,25 mm latae, parum bilabiatae, labio interiore parvulo, infra laeves, atro-virides, supra pallescentes, perleniter rugulosae, recurvae; lobi 5, subquadrati, c. 1 mm longi, ir-

Accepted for publication 13th January, 1983.

regulariter fimbriati, utrinque pilosi. *Involucrum*, femineum intus glabrum, apice piloso excepto; florum, seporum, bracteolarumque vestigiis instructum. *Flos femineus*, pedicello sparsim minute puberulo, c. 0,5 mm longo suffultus; ovarium subglobosum subsessile; stylis crassis, in columnam basi connatis, partibus libris patulo-recurvis, ad apicem breviter bifidis, lobis patulis valde recurvis. *Involucrum* masculinum intus versus apicem pilosum, septis 5; septa ad medium in lobis duobus plumosis bracteoliformibus divisa. Flores masculi c. 40, aliquot bracteolis plumosis, c. 2 mm longis; *pedicelli* pubescentes, albidii; *filamenta* pallide viridia, minute puberula, c. 0,75 mm longa; *antheris* atro-viridibus, polline flavido-aurantiaco. *Capsula* glabra, tantum ex involucri reliquiis exserta, subglobosa, leviter 3-sulcata, atro-brunnea, c. 5,75 mm diam., 4,75 mm alta. *Semen* late subovoidium, leviter ruminatoglobulosum, brunneo-cremeum, c. 3,5 mm \times 2,5 mm.

Typus: S.W.A., Namuskluft, Lavranos & Pehlemann 20796 (PRE, holo; WIND).

Plant dioecious, much-branched, unarmed, succulent, rhizomatose-tuberous rooted, with the above ground crowded branches and branchlets seldom attaining 20 mm in height (plants in cultivation may develop branches up to 60 mm or more long, while rhizome-like underground branches are often longer). *Branches* and *branchlets* tuberculate, estipulate, micro-scabridulous, \pm 5 mm thick. *Leaves* ovate acute, \pm 1,5 mm long, spreading recurved, somewhat folded, fleshy, variably micro-scabridulous, deciduous, leaving a brown scar at the apex of the tubercle. *Inflorescence* axillary, at the apex of the branches, usually a single unisexual cyathium borne on a short, glabrous, bracteate peduncle with a pseudo-whorl of three bracts below the cyathium. *Bracts* quite different from the leaves, especially in the male plant, \pm oblong, somewhat obtuse, irregularly denticulate, with a narrow subpellucid border, usually with a shortly folded, recurved, acute apicula, often somewhat pubescent on the upper surface. *Cyathium* glabrous or rarely very sparsely micro-scabridulous, green at the base becoming purplish above, 2–3 mm long, \pm 3 mm in diam.; *glands* 5, erect, somewhat cuneate, 1–2.25 mm broad, slightly two-lipped, with a thickened rim and a small central lip on the inner margin, slightly concave, dark green, smooth below, becoming pale on the very faintly rugulose, recurved outer margin; *lobes* 5, subquadrate, \pm 1 mm long, irregularly fimbriate, pilose both sides, more densely within. *Involucre* ♀, glabrous inside, except towards the apex, there pilose, particularly densely below the gland, with the rudiments of septa, ♂ flowers and bracteoles around the base (unusual in ♀ cyathia of unisexual species); ♀ flower, almost subsessile, *pedicel* sparsely minutely puberulous, \pm 0,5 mm long; *perianth* rim-like; *ovary* subglobose; *styles* very stout, united at the base into a short stout column, \pm 0,6 mm thick, \pm

0,5 mm long, the free portions spreading recurved. Male flowers, ± 40 , with a few plumose bracteoles, ± 2 mm long; *pedicels* ± 2 mm long, pubescent, whitish; *filaments* $\pm 0,75$ mm long, pale green, minutely puberulous; anther thecae dark green with yellow-orange pollen. *Capsule* glabrous, barely exerted from the remains of the cyathium, subglobose, shallowly 3-grooved, dark brown, $\pm 5,75$ mm diam., 4,75 mm high. *Seed* broadly sub-ovoid, shallowly ruminant-glebulose, brownish cream, $\pm 3,5$ mm \times 2,5 mm.

MATERIAL EXAMINED

SOUTH WEST AFRICA—2716 (Witputz): Namuskluft (-DD), 1 200 m alt., restricted to white limestone outcrop. st. Oct. 1978. *Lavranos & Newton 16871* (K), cult. PRE, ♀ Sept. 1982. *Lavranos & Newton 17167* (PRE, WIND), *Lavranos & Pehlemann 20796* ♂ (PRE, WIND), 20797 ♀, fr. (PRE).

Euphorbia namuskluftensis is virtually indistinguishable from *E. wilmaniae* in habit and vegetative characters but differs widely in its floral, with



FIG. 1.

Euphorbia namuskluftensis Leach. sp. nov. 1. Male cyathia; 2. Female cyathia; 3. Peduncular bracts; 4. Fascicle of male flowers; 5. Bracteole; 6. Lobe; 7. Gland (flattened); 8. Female flower; 9. Female involucre.

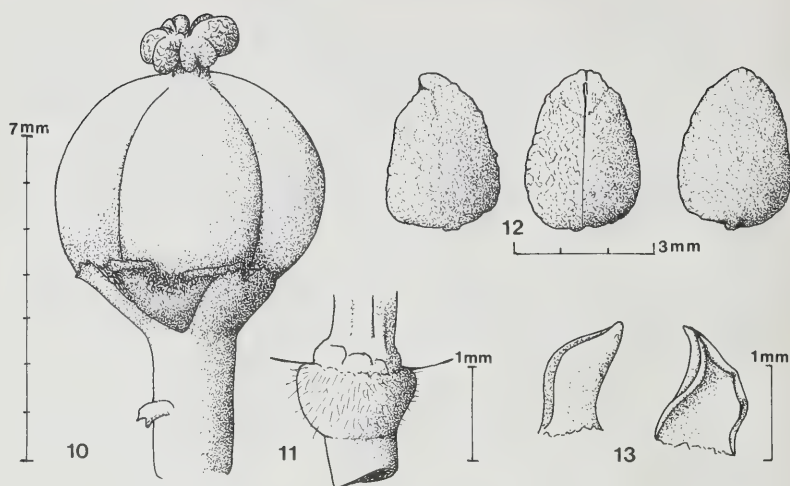


FIG. 2.

Euphorbia namuskluftensis Leach, sp. nov. 10. Mature capsule; 11. Perianth; 12. Seed; 13. Leaf.

smooth (not prominently rugose) glands which lack any sign of the characteristic finger-like processes of that species, and a sessile capsule with smaller proportionally narrower seeds.

This species has been found only on a white limestone outcrop on the Namuskluft, where it is associated with the recently described *E. lavrani* Leach. As with that species, the only plant in cultivation at PRE was female, and although clearly quite different from *E. wilmaniae* it was considered that the material available was inadequate for its publication as a new species. I am consequently most grateful to John Lavranos for returning to the locality and collecting a male plant with adequate mature material.

A CHECK-LIST OF THE PTERIDOPHYTES OF ZIMBABWE

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ABSTRACT

The two hundred and thirty-four species of ferns and fern allies indigenous or naturalised in Zimbabwe are listed, thereby up-dating E. A. Schelpe's (1970) treatment by including new records and name changes effected since his publication.

UITTREKSEL

'N KONTROLELYS VAN DIE PTERIDOFIETE VAN ZIMBABWE

Die tweehonderd vier-en-dertig varingsoorte en varingagtiges, inheems of genaturaliseerd in Zimbabwe word aangegee en so word E. A. Schelpe se (1970) verhandeling op datum gebring deur die insluiting van nuwe varingsoorte en naamveranderings sedert sy publikasie.

Key words: Pteridophytes, Zimbabwe, ferns.

INTRODUCTION

The following is a check-list of the ferns and fern allies occurring in Zimbabwe. Since the publication of Schelpe's *Pteridophyta* for the *Flora Zambesiaca* (1970), there have been several new records, new taxa described and several name changes making an up-dated check-list desirable.

The arrangement and numbering of families and genera follows Crabbe, Jermy and Mickel's numerical sequence (1975). Although differing radically from Schelpe's treatment, this is now a more widely accepted arrangement. Schelpe's basic generic concept has nevertheless been followed, with a few exceptions.

Synonyms have been printed in italics, and since much of the origin of Zimbabwean synonymy dates from T. R. Sim's *Ferns of South Africa* (1915), synonyms and misapplied names from this source are also provided in the list.

References to recent generic or family revisions since the *Flora Zambesiaca* volume on *Pteridophyta* was published are given under the relevant taxa.

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Accepted for publication 17th January, 1983.

Distribution of species in surrounding territories is indicated in the list by numerals, as follows:

- 0 Endemic to Zimbabwe or so far only recorded from Zimbabwe
- 1 Botswana
- 2 Zambia
- 3 Malawi
- 4 Mozambique
- 5 Area covered by the flora of southern Africa, but excluding Botswana (i.e. Republic of South Africa, Transkei, Lesotho, Swaziland, Bophuthatswana, Namibia and the Caprivi Strip).

Where species do not occur in any of the countries adjacent to Zimbabwe, but are found elsewhere in Africa or the Indian Ocean islands, the nearest locality to Zimbabwe is listed.

A specimen is cited for each taxon. Where possible specimens have been cited which are housed in the National Herbarium of Zimbabwe (SRGH), with duplicates in two or more of the following herbaria: K, BOL, BM, PRE, LISC. Where a species is described from Zimbabwe the specimen quoted is the type and the collector's name italicised.

Introduced species which have now become naturalised in parts of the country are indicated by an asterisk. Cultivated plants are not included in the list.

The habitat or life-form is indicated as follows:

- E epiphytic
- L lithophytic
- T terrestrial
- A aquatic
- C climber

Where a species is able to grow in more than one habitat, more than one letter is given, e.g. ETL. The term lithophytic is here given to plants which adhere to a rock surface, whether bare or covered with a layer of moss or lichen. Where a plant grows in a deposit of soil or humic matter on top of, or among rocks, it has been classified as terrestrial. Aquatics are either free-floating or rooted in water for all or part of the year, but the term does not include waterside plants.

Distribution within Zimbabwe is indicated by letters which show the geographical divisions as used in the *Flora Zambesiaca*: N, W, C, E, S (see Fig. 1).

ACKNOWLEDGEMENTS

The assistance of the following persons is gratefully acknowledged; Professor E. A. Schelpe and Mrs. N. C. Anthony of the Bolus Herbarium,

Cape Town; Mr. R. B. Drummond and Mr. G. V. Pope of the National Herbarium, Harare.

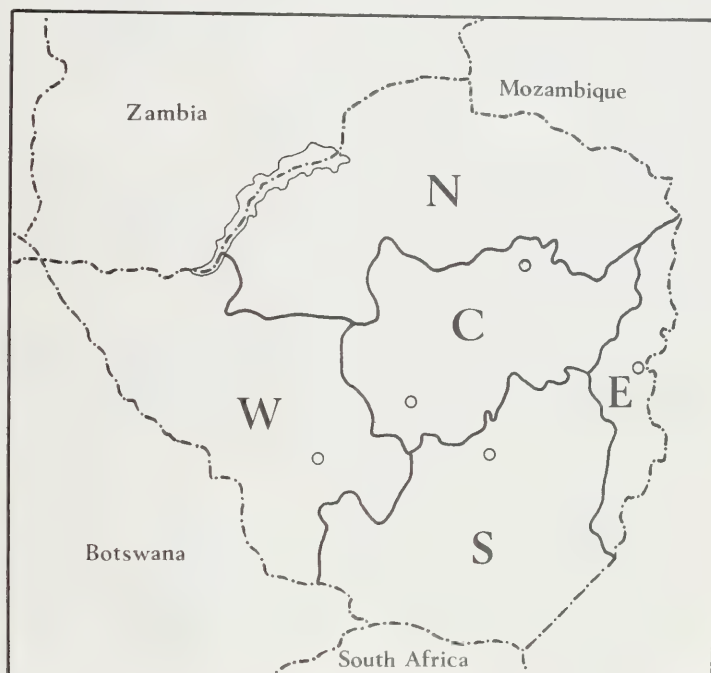


FIG. 1.
The geographical divisions of Zimbabwe.

PSILOTACEAE

- 001 *Psilotum* Sw.
P. nudum (L.) Beauv. 245 NWCES Wild 6601 LE

LYCOPODIACEAE

- 003 *Lycopodium* L.
L. carolinianum L. 234 E Goodier & Phipps 229 T
 var. *affine* (Bory) Schelpe 2345 WES Robinson 1932 T
 var. *grandifolium* Spring 2345 NWCES Miller 5895 T
L. cernuum L. 2345 NWCES Miller 5895 T
L. clavatum L.
 var. *inflexum* (Beauv.) Spring 2345 E Chase 4507 T
L. dacrydioides Bak. 345 E Muller 3407 E

Lycopodium L.

<i>L. gnidioides</i> L.f.	345	E	Goodier 170	LE
<i>L. ophioglossoides</i> Lam.	345	E	Chase 3182	LE
<i>L. saururus</i> Lam.	35	E	W. Jacobsen 3745	LT
<i>L. verticillatum</i> L.f.	2345	E	Mitchell 502	LE

SELAGINELLACEAE**008 Selaginella Beauv.**

<i>S. abyssinica</i> Spring	234	NE	Chase 5041	LT
<i>S. caffrorum</i> (Milde) Hieron.	5	S	J. Burrows 2691	L
<i>S. dregei</i> (C.Presl) Hieron.	12345	NWCES	Chase 5188	TL
<i>S. imbricata</i> (Forsk.) Spring ex Decne.	245	NW	Chase 5763	T
<i>S. kraussiana</i> (Kunze) A.Braun	345	E	Wild 3563	T
<i>S. mittenii</i> Bak.	2345	NWCES	Pope 126	T
<i>S. nivea</i> Alston	4	S	Leach & Cannell 14894	T
<i>S. perpusilla</i> Bak.	Tanzania	S	Drummond 7851	T

ISOETACEAE**009 Isoetes L.**

<i>I. aequinoctialis</i> Welw. ex A.Braun	25	N	Whellan 849	A
<i>I. schweinfurthii</i> A.Braun	125	WS	Drummond & Rutherford-Smith 7557 & 7557a	A
<i>I. alstonii</i> Reed & Verdcourt			Greenway & Brenan 8012	
<i>I. rhodesiana</i> Alston			West 3075	

EQUISETACEAE**011 Equisetum L.**

<i>E. ramosissimum</i> Desf.	2345	NWCES	Phipps 864	T
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OPHIOGLOSSACEAE**016 Ophioglossum L.**

<i>O. costatum</i> R.Br.	234	NWCES	Drummond 5452	T
<i>O. gomezianum</i> Welw. ex A.Braun	235	NCES	Drummond 5102	T
<i>O. lancifolium</i> C.Presl	23	NWE	Mitchell 406	T
<i>O. polyphyllum</i> A.Braun	1345	NCES	Phipps 1463	T
<i>O. reticulatum</i> L.	2345	NWCES	J. Burrows 2083	T
<i>O. vulgatum</i> L.	2345	NCE	Chase 5913	T
<i>O. vulgatum</i> var. <i>kilimandscharicum</i> Hieron.				

MARATTIACEAE

- 022 **Marattia** Sw.
M. fraxinea Sm. ex
 J.F.Gmel.
 var. *salicifolia* (Schrad.)
 C.Chr. 2345 ES Chase 4508 T

OSMUNDACEAE

- 026 **Osmunda** L.
O. regalis L. 2345 NWCES Plowes 1739 T
- 029 **Todea** Willd.
T. barbara (L.) Moore 45 E Mitchell 278 T

SCHIZAEACEAE

- 032 **Schizaea** Sm.
S. pectinata (L.) Sw. 345 E J. Burrows 2440 T
S. tenella Kaulf. 5 E J. Burrows 2410 T
- 034 **Lygodium** Kuhn
L. kerstenii Kuhn 245 ES Chase 6975 TC
L. brycei Bak. *Bryce s.n.*
- 035 **Anemia** Sw.
A. angolensis Alston 23 N Phipps 956 T
A. simii var. *angustiloba*
 (Bonap.) P.-Sermolli
A. simii Tardieu 45 NCES Eyles 726 T
A. anthriscifolia sensu Sim
- 036 **Mohria** Sw.
M. caffrorum (L.) Desv. 2345 NCES Chase 7033 T
M. lepigera (Bak.) Bak. 234 WCES J. Burrows 2577 T

PARKERIACEAE

- 037 **Ceratopteris** Brongn.
C. cornuta (Beauv.) Le
 Prieur 124 NW Guy 1866 A
C. thalictroides sensu
 Schelpe

ADIANTACEAE

- 039 **Actiniopteris** Link
A. dimorpha P.-Sermolli 2345 NWCES Rodin 4407 LT
A. pauciloba P.-Sermolli 2 N Mitchell 560 LT
A. radiata (Sw.) Link 125 NWES Phipps 919 LT

047 *Cheilanthes* Sw.Anthony, N. C. & Schelpe, E. A. C. L. E. in Contr. Bol. Herb. **10**: 143–164 (1982)

<i>C. bergiana</i> Schlechtend.	345	E	Chase 5990	T
<i>C. concolor</i> (Langsd. & Fisch.) Schelpe & N.C. Anthony	12345	NWCES	Chase 6802	LT
<i>Doryopteris concolor</i> (Langsd. & Fisch.) Kuhn				
<i>C. eckloniana</i> (Kunze) Mett.	5	CES	Rushworth 803	T
<i>Notholaena eckloniana</i> Kunze				
<i>C. farinosa</i> (Forsk.) Kaulf.	23	WCE	Schelpe 3930	ET
<i>C. hirta</i> Sw.	145	NWCES	Rodin 4351	T
<i>C. inaequalis</i> (Kunze) Mett. var. <i>inaequalis</i>	235	NWCES	Fisher & Schweickerdt 476	LT
<i>Notholaena inaequalis</i> Kunze				
var. <i>buchananii</i> (Bak.) Schelpe	245	CES	Chase 7739	LT
<i>Notholaena buchananii</i> Bak.				
<i>C. leachii</i> (Schelpe) Schelpe	234	WCES	Pope 1108	T
<i>Notholaena leachii</i> Schelpe				
<i>C. multifida</i> (Sw.) Sw. subsp. <i>multifida</i>	5	S	J. Burrows 39	T
subsp. <i>lacerata</i> N.C. Anthony & Schelpe	2345	NWCES	Chase 6404	T
<i>C. pentagona</i> Schelpe & N.C. Anthony	5	N	Mitchell 105	T
<i>C. quadripinnata</i> (Forsk.) Kuhn	345	NCE	Wild 1397	T
<i>Pellaea quadripinnata</i> (Forsk.) Prantl				
<i>C. viridis</i> (Forsk.) Sw. var. <i>viridis</i>	345	WCES	Wild 2187	T
<i>Pellaea viridis</i> (Forsk.) Prantl				
var. <i>viridis</i>				
var. <i>glauca</i> (Sim) Schelpe & N.C. Anthony	12345	NWCES	J. Burrows 2654	T
<i>Pellaea viridis</i> (Forsk.) Prantl				
var. <i>glauca</i> (Sim) Sim				
var. <i>obscura</i> N.C. Anthony	45	NWCES	H. Burrows 1942	T
<i>Pellaea viridis</i> (Forsk.) Prantl				
var. <i>involuta</i> sensu Schelpe				

	Cheilanthes welwitschii Hook, ex Bak.	4	NC	Mitchell 477	T
	<i>C. mossambicensis</i> Schelpe				
050	Aspidotis (Nutt. ex Hook.) Copel.				
	<i>A. schimperi</i> (Kunze)				
	<i>P.-Sermolli</i>	234	NCE	Chase 4747	T
	<i>Hypolepis schimperi</i> (Kunze) Hook.				
057	Pellaea Link				
	<i>P. boivinii</i> Hook.	25	NWCES	Chase 6163	T
	<i>P. calomelanos</i> (Sw.) Link				
	var. <i>calomelanos</i>	12345	NWCES	Miller 2786	T
	<i>Pellaea hastata</i> sensu Sim				
	var. <i>swynnertoniana</i> (Sim) Schelpe	34	ES	Schelpe 5393	T
	<i>P. swynnertoniana</i> Sim			<i>Swynnerton 850</i>	
	<i>P. doniana</i> J.Sm. ex Hook.	234	NES	Chase 7491	T
	<i>P. dura</i> (Willd.) Hook.	2345	NWCES	Chase 6230	T
	<i>P. longipilosa</i> Bonap.	234	NC	Rodin 4427	T
	<i>P. pectiniformis</i> Bak.	2345	NCES	Chase 3494	LT
	<i>P. goudotii</i> C.Chr.				
062	Anogramma Link				
	<i>A. leptophylla</i> (L.) Link	5	NE	Eyles 563	T
063	Pityrogramma Link				
	<i>P. argentea</i> (Willd.) Domin	2345	NCES	Schelpe 5662	LT
	<i>Gymnogramma argentea</i> (Willd.) Mett.				
086	Adiantum L..				
	<i>A. capillus-veneris</i> L.	2345	NWCES	Greenway & Brennan 8027	ELT
	<i>A. hispidulum</i> Sw.	34(5*)	E	J. Burrows 2160	T
	<i>A. incisum</i> Forsk.	2345	NWCES	Schelpe 4084	LT
	<i>A. caudatum</i> sensu Sim				
	<i>A. mendoncae</i> Alston	4	NES	Mitchell 404	T
	<i>A. patens</i> Willd.				
	subsp. <i>oatesii</i> (Bak.) Schelpe	2	W	J. Burrows 2630	T
	<i>A. oatesii</i> Bak.			<i>Oates s.n.</i>	
	<i>A. philippense</i> L.	2345	NWCE	Rogers 5549	LT
	<i>A. lunulatum</i> Burm.f.				
	<i>A. poiretii</i> Wikstr.				
	var. <i>poiretti</i>	2345	NWCES	Eyles 328	LT
	<i>A. thalictroides</i> Willd. ex Schlechtend.				
	var. <i>sulphureum</i> (Kaulf.) Tryon	35	NCE	Chase 6536	LT
	* <i>A. raddianum</i> C.Presl	345	E	Chase 6343	T

093 *Vittaria* Sm.

<i>V. elongata</i> Sw.	4	E	J. Burrows 2761	E
<i>V. guineensis</i> Desv.				
var. <i>orientalis</i> Hieron.	234	E	Chase 6641	TLE
<i>V. isoetifolia</i> Bory	345	E	Fisher 1571	LE
<i>V. volkensii</i> Hieron.	34	E	Mitchell 268	LE

096 *Pteris* L.

Schelpe, E.A.C.L.E., in Contr. Bol. Herb. 1: 57-67 (1969)				
<i>P. buchananii</i> Bak. ex Sim	5	E	Wild 2216	T
<i>P. cretica</i> L.	235	CES	Chase 3525	T
<i>P. dentata</i> Forsk.	2345	E	Chase 6240	T
<i>P. dentata</i> Forsk.				
subsp. <i>flabellata</i> (Thunb.)				
Runemark				
<i>P. pteridioides</i> (Hook.)				
Ballard	34	E	Wild 2199	T
<i>P. quadriaurita</i> Retz.				
subsp. <i>catoptera</i> (Kunze)				
Schelpe	2345	NE	Wild 2204	T
<i>P. catoptera</i> Kunze				
var. <i>horridula</i> Schelpe	34	E	Chase 4890	T
subsp. <i>friesii</i> (Hieron.)				
Schelpe	2345	WCES	Mitchell 563	T
<i>P. friesii</i> Hieron				
<i>P. vittata</i> L.	2345	NWCES	Gilliland 203	T
<i>P. mildbraedii</i> Hieron.	Zaire	E	J. Burrows 2822	T

100 *Acrostichum* L.

<i>A. aureum</i> L.	45	S	Jaklitsch s.n.	T
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HYMENOPHYLLACEAE

106 *Hymenophyllum* Sm.

<i>H. capense</i> Schrad.	345	E	J. Burrows 2681	LE
<i>H. polyanthos</i> var.				
<i>mossambicense</i> sensu				
Schelpe				
<i>H. capillare</i> Desv.	345	E	Chase 3187	LE
<i>H. hirsutum</i> sensu Schelpe				
& Diniz	4	E	J. Burrows 2936	L
<i>H. polyanthos</i> Sw.				
var. <i>kuhnii</i> (C. Chr.)				
Schelpe	34	E	Fisher & Schweickardt 321	LE
<i>H. henkelii</i> Sim				
<i>H. sibthorpioides</i> (Bory ex Willd.) Mett. ex Kuhn	34	E	Müller 3248	LE
<i>H. tunbridgense</i> (L.) Sm.	345	E	Chase 6678	LE

117 **Trichomanes** L.

<i>T. borbonicum</i> v.d.Bosch	345	E	Chase 6573	LE
<i>T. erosum</i> Willd.				
var. <i>erosum</i>	4	E	Chase 5851	LE
var. <i>aerugineum</i> (v.d.Bosch) Schelpe	45	E	J. Burrows 2790	L
<i>T. pyxidiferum</i> L.				
var. <i>melanotrichum</i> (Schlechtend.) Schelpe	2345	E	Eyles 4451	LE
<i>T. rigidum</i> Sw.	2345	E	Wild 3635	T

GLEICHENIACEAE

144 **Gleichenia** Sm.

<i>G. polypodioides</i> (L.) Sm.	345	NES	Chase 6743	T
<i>G. umbraculifera</i> (Kunze) Moore	5	E	Wild 1475	T

147 **Dicranopteris** Bernh.

<i>D. linearis</i> (Burm.f.) Underw.	2345	NES	Chase 7870	T
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POLYPODIACEAE

162 **Platyserium** Desv.

<i>P. alpicorne</i> Desv.	4	E	Biegel 2758	E
<i>P. vassei</i> Poisson				
<i>P. bifurcatum</i> sensu Sim				

163 **Pyrrosia** Mirb.

<i>P. lanceolata</i> (L.) Farw.	4	E	J. Burrows 2724	LE
<i>P. rhodesiana</i> (C. Chr.) Schelpe	34	E	Eyles 4472	LE
<i>P. schimperana</i> (Mett. ex Kuhn) Alston	2345	NCES	Chase 6577	LE

166 **Microsorium** Link

Schelpe, E.A.C.L.E., in Con. Fl. Angol., Pterid. Vol.: 121-124 (1977).				
<i>M. pappei</i> (Mett. ex Kuhn) Tardieu	45	E	J. Burrows 2163	LE
<i>M. punctatum</i> (L.) Copel.	345	E	Wild & Chase 5571	LE
<i>M. scolopendrium</i> (Burm.f.) Copel.	45	E	Chase 6669	TLE
<i>Phymatodes scolopendria</i> (Burm.f.) Ching				

185 **Pleopeltis** Willd.

<i>P. excavata</i> (Bory ex Willd.) Sledge	2345	NE	Chase 6669	LE
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Pleopeltis macrocarpa (Bory ex Willd.) Kaulf.					
	2345	CES	Wild 4311		LE
P. schraderi (Matt.) Tardieu					
	345	ES	Chase 6568		LE
186 Microgramma C.Presl					
M. lycopodioides (L.) Copel.					
	245	E	J. Burrows 2725		LE
196 Belvisia Mirb.					
B. spicata (L.f.) Mirb.					
	4	E	Chase 7196		E
206 Polypodium L.					
P. polypodioides (L.) Hitchcock					
subsp. ecklonii (Kunze) Schelpe					
	345	CES	Wild 2119a		LE

GRAMMITIDACEAE

210 Grammitis Sm.					
G. nanodes (A.Peter) Ching					
	4	E	Mitchell 364		LE
211 Xiphopteris Kaulf.					
X. flabelliformis (Poir.) Schelpe					
	345	E	Mitchell 366		LE
X. oosora (Bak.) Alston					
	3	E	J. Burrows 2840		L
X. serrulata (Sw.) Kaulf.					
	Congo	E	Williams 11		L
223 Loxogramme (Bl.) C.Presl.					
L. lanceolata (Sw.) C.Presl					
	2345	ES	Chase 6665		LE

CYATHEACEAE

228 Cyathea Sm.					
Holtum, R. E. in Kew Bulletin 36 (3): 463-482 (1981)					
Tryon, R. in Contr. Gray Herb. 200 : 3-53 (1970)					
C. capensis (L.f.) Sm.					
	345	E	J. Burrows 2547		T
Hemitelia capensis (L.f.) Kaulf.					
Alsophila capensis (L.f.) J.Sm.					
C. dregei Kunze					
	2345	NWCES	Chase 6894		T
Alsophila dregei (Kunze) Tryon					
C. manniana Hook.					
	234	E	Chase 6696		T
Alsophila manniana (Hook.) Tryon					
C. mossambicensis Bak.					
	4	E	J. Burrows 2788		T
Alsophila mossambicensis (Bak.) Tryon					
C. thomsonii Bak.					
	234	ES	Chase 6864		T
Alsophila thomsonii (Bak.) Tyron					

Thelypteris dentata (Forsk.)

E.St.John

var. *dentata*

2345 NWCES Chase 6165 T

Cyclosorus hispidulus

A.Peter

*Peter 30794**Christella dentata* (Forsk.)

Holtz.

var. *buchananii* Schelpe

45 E Mitchell 401 T

T. friesii (Brause) Schelpe

23 E Chase 4628 T

Christella friesii (Brause)

Holtz.

T. gueinziana (Mett.)

Schelpe

345 NWCES Chase 6167 T

Christella gueinziana (Mett.)

Holtz.

T. hispidula (Decne.) Reed

234 E Wild 2188 T

T. quadrangularis (Fée)

Schelpe

Christella hilsenbergii

(C.Presl) Holtz.

T. hilsenbergii (C.Presl)

Schelpe

Christella hispidula (Decne.)

Holtz.

T. interrupta (Willd.)

K.Iwats.

123 NE Chase 3099 AT

Cyclosorus interruptus

(Willd.) H.Ito

T. madagascariensis (Fée)

Schelpe

2345 E Swynnerton 864 T

Pneumatopteris unita

(Kunze) Holtz.

T. oppositiformis (C.Chr.)

Ching

Tanzania E Schelpe 5670 LT

T. strigosa sensu Schelpe*Amauropelta oppositiformis*

(C.Chr.) Holtz.

T. pozoi (Lagasca) Morton

35 E Chase 5667 LT

Stenogramma pozoi

(Lagasca) K.Iwats

T. pulchra (Bory ex Willd.)

Schelpe

3 CES Mitchell 745 T

T. longicuspis (Bak.)

Schelpe

Pseudocyclosorus pulcher

(Bory ex Willd.) Holtz.

T. totta (Thunb.) Schelpe

345 S J. Burrows 2657 AT

Dryopteris gongylodes

(Schkuhr) Kuntze

Cyclosorus tottus (Thunb.)

P.-Sermolli

282 *Ampelopteris* Kunze

<i>A. prolifera</i> (Retz.) Copel	2345	NWES	Chase 6540	T
-----------------------------------	------	------	------------	---

ASPLENIACEAE

288 *Asplenium* L.

<i>A. aethiopicum</i> (Burm.f.) Becherer	2345	NWCES	Miller 2603	TEL
<i>A. praemorsum</i> sensu Sim				
<i>A. lividum</i> sensu Schelpe				
<i>A. anisophyllum</i> Kunze	345	E	Chase 1011	ELT
<i>A. atroviride</i> Schelpe	34	E	<i>Schelpe 5446</i>	T
<i>A. auritum</i> Sw.	4	E	Chase 6558	T
<i>A. blastophorum</i> Hieron.	2345	E	Swynnerton 845a	T
<i>A. boltonii</i> Hook. ex Schelpe	2345	ES	Chase 2038	ELT
<i>A. christii</i> Hieron.	5	ES	Fisher & Schweickerd 384	T
<i>A. dregeanum</i> Kunze	2345	E	Chase 1115	T
<i>A. erectum</i> Bory ex Willd. var. <i>usambarense</i> (Hieron.) Schelpe	2345	ES	Chase 6693	T
<i>A. formosum</i> Willd.	234	E	Chase 3517	ETL
<i>A. friesiorum</i> C. Chr.	2345	E	Mitchell 266	ETL
<i>A. gemmiferum</i> Schrad.	345	E	Chase 6227	TL
<i>A. holstii</i> Hieron.	34	E	Mitchell 377	T
<i>A. hypomelas</i> Kuhn	34	ES	Fisher & Schweickerd 309	T
<i>Davallia hollandii</i> Sim			<i>Holland s.n.</i>	
<i>A. hollandii</i> (Sim) C. Chr.				
<i>A. inaequilaterale</i> Willd.	2345	E	Wild 2198	LT
<i>A. erectum</i> Bory ex Willd. var. <i>brachyotus</i> (Kunze) Sim				
<i>A. linckii</i> Kuhn	3	E	Chase 6576	T
<i>A. lobatum</i> Pappe & Raws. var. <i>lobatum</i>	345	E	Chase 3032	LT
<i>A. erectum</i> var. <i>lobatum</i> (Pappe & Raws.) Alston & Schelpe				
<i>A. lunulatum</i> var. <i>gracile</i> Sim				
var. <i>pseudoabyssinicum</i> Schelpe & N. C. Anthony	4	E	Chase 7145	ELT
<i>A. mannii</i> Hook.	234	E	Fisher & Schweickerd 219	LE
<i>A. monanthes</i> L.	35	E	Chase 3047	T
<i>A. mossambicense</i> Schelpe	4	E	Wild 2203	T
<i>A. obscurum</i> Bl.	34	E	Mitchell 405	TL
<i>A. parablastophorum</i> <i>A. Braithwaite</i>	0	E	<i>Mitchell 381</i>	T

Asplenium pellucidum Lam.					
subsp. pseudohorridum					
(Hieron.) Schelpe	4	E	Mitchell 380	LT	
A. preussii Hieron.	34	E	J. Burrows 1667	T	
A. pseudoauriculatum					
Schelpe					
A. protensum Schrad.	2345	E	Chase 6690	LT	
A. pumilum Sw.					
subsp. hymenophylloides					
(Fée) Schelpe	23	N	Rodin 4360	LT	
A. eylesii Sim			<i>Eyles 564</i>		
A. ramlowii Hieron.	24	NWCES	Chase 6316	LT	
A. rutifolium (Berg.) Kunze					
var. rutifolium	5	E	Ball s.n.	LET	
var. bipinnatum (Forsk.)					
Schelpe	345	ES	Mitchell 282	LET	
A. sandersonii Hook.	345	E	Fisher 1098	LE	
A. schelpei Braithwaite	5	E	Chase 5688	LT	
A. simii Braithwaite & Schelpe					
	45	E	<i>Chase 6274</i>	LE	
A. cuneatum . var.					
angustatum Sim					
A. theciferum (Kunth) Mett.					
var. concinnum (Schrad.)					
Schelpe	2345	ES	Chase 2046	LE	
A. trichomanes L.	5	E	J. Burrows 2088	TL	
A. unilaterale Lam.	3	E	Taylor 3380	TL	
A. varians Wall. ex Hook. & Grev.					
subsp. fimbriatum					
(Kunze) Schelpe	45	ES	Chase 5124	LT	
291 Ceterach DC.					
C. cordatum (Thunb.) Desv.	15	NWCES	Miller 5501	T	
Asplenium cordatum (Thunb.) Sw.					
304 Athyrium Roth.					
A. scandicinum (Willd.) C.Presl					
var. scandicinum	345	E	Chase 2199	T	
var. rhodesianum Schelpe	0	E	<i>Schelpe 5722</i>	T	
A. schimperi Moug. ex Fée	235	CE	Chase 3774	T	
307 Diplazium Sw.					
D. nemorale (Bak.) Schelpe	4	E	Chase 5700	T	
D. zanzibaricum (Bak.) C.Chr.	245	E	Chase 6181	T	
321 Dryothyrium Ching					
D. boryanum (Willd.) Ching	4	E	Chase 6182	T	
Athyrium glabratum (Mett. ex Kuhn) Alston					
Parathyrium boryanum (Willd.) Holtt.					

- 328 **Ctenitis** (C.Chr.) C.Chr. ex Tardieu
C. cirrhosa (Schum.) Ching 234 E Chase 5127 T
C. lanuginosa (Willd. ex Kaulf.) Copel. 345 E J. Burrows 2122 T
Dryopteris lanuginosa
(Willd. ex Kaulf.) C.Chr.
- 337 **Tectaria** Cav.
T. gemmifera (Fée) Alston 2345 E Chase 5715 T
- 353 **Didymochlaena** Desv.
D. truncatula (Sw.) J.Sm. 345 E Gilliland 1747 T
- 356 **Polystichum** Roth.
P. luctuosum (Kunze) Moore 5 E Chase 1083 T
P. transvaalense N.C. Anthony 35 E Chase 7482 T
P. setiferum sensu Schelpe 34 E Schelpe 5751 T
P. zambesiaceum Schelpe
- 364 **Arachniodes** Bl.
A. foliosa (C.Chr.) Schelpe 25 E J. Burrows 2227 T
Dryopteris foliosa C.Chr.
- 369 **Dryopteris** Adans.
D. athamantica (Kunze) Kuntze 2345 CES Mitchell 45 T
D. callolepis C.Chr. 5 E Chase 5262 T
D. inaequalis (Schlechtend.) Kuntze 2345 NCES Chase 6531 T
D. kilemensis (Kuhn) Kuntze 234 E Chase 5390 T
D. lastii (Bak.) C.Chr.
D. manniana (Hook.) C.Chr. 34 E J. Burrows 1676 T
D. squamiseta (Hook.) Kuntze 25 E Chase 4640 T
D. buchananii (Bak.) Kuntze
D. wallichiana (Spreng.) Hylander Malagasy Rep. E Chase 7337 T
- 374 **Bolbitis** Schott
B. gemmifera (Hieron.) C.Chr. Angola E Biegel 2827 T
B. heudelotii (Bory ex Fée) Alston 245 NE Chase 6638 LA

380 **Lomariopsis** Fée

L. warneckei (Hieron.)

Alston

34

E

J. Burrows 2116

E

L. nigrescens Holtt.

381 **Elaphoglossum** Schott

E. acrostichoides (Hook. &

Grev.) Schelpe

345

E

Chase 3792

EL

E. conforme var. lineatum

(Kuhn ex Christ) C. Chr.

E. aubertii (Desv.) Moore

345

E

Chase 4509

L

E. chevalieri Christ

34

E

Chase 6667

EL

E. deckenii (Kuhn) C. Chr.

3

E

J. Burrows 2841

EL

E. hybridum (Bory) Brack.

345

E

Chase 6666

ETL

E. kuhnii Hieron.

3

CE

Schelpe 5647

TL

E. lastii (Bak.) C. Chr.

34

E

Fisher & Schweickhardt
326

E

E. macropodium (Fée)

Moore

345

E

Schelpe 5742

LE

E. conforme var. latifolium

sensu Sim

E. marojejyense Tardieu

Malagasy
Rep.

E

Mitchell 367

L

E. petiolatum (Sw.) Urb.

subsp. salicifolium (Willd.

ex Kaulf.) Schelpe

234

E

Chase 3308

EL

E. spathulatum (Bory)

Moore

2345

NE

Drummond 6049

L

E. spathulatum var.

uluguruense (Reim.)

Schelpe

DAVALLIACEAE

388 **Davallia** Sm.

D. chaerophylloides (Poir.)

Steud.

45

E

Chase 2190

EL

394 **Rumohra** Raddi

R. adiantiformis (Forst.)

Ching

5

E

J. Burrows 2262

T

395 **Oleandra** Cav.

O. distenta Kunze

2345

NCE

Chase 6912

ETL

396 **Arthropteris** J. Sm.

A. monocarpa (Cordem.)

C. Chr.

2345

CE

Chase 4499

ETL

A. orientalis (J.F. Gmel.)

Posth.

234

NWCE

Chase 6406

TL

398 **Nephrolepis** Schott

N. biserrata (Sw.) Schott

N. undulata (Afz. ex Sw.)

J. Sm.

245

E

Biegel 2779

ETL

234

NWCE

Davies 978

T

BLECHNACEAE

- 399 **Blechnum** L.
B. attenuatum (Sw.) Mett. 235 E Chase 6645 EL
B. australe L. 5 E Fisher 1257 T
B. giganteum (Kaulf.) Schlechtend. 345 CE Swynnerton 835a LT
B. attenuatum
var. *giganteum*
B. inflexum (Kunze) Kuhn 5 E Fisher 1428 T
B. ivohibense C. Chr. 4 E J. Burrows 2839 T
B. punctulatum Sw. 35 NS J. Burrows 2695 TL
B. sylvaticum Schelpe 345 E Chase 4268 T
B. capense (L.) Schlechtend.
B. tabulare (Thunb.) Kuhn 2345 CE Chase 7134 T
- 409 **Stenochlaena** J.Sm.
S. tenuifolia (Desv.) Moore 45 E J. Burrows 2780 TC

MARSILEACEAE

- 410 **Marsilea** L.
M. apposita Launert 15 NW Gibbs 289 A
M. coromandelina Willd. 5 S Ngoni 137 A
M. ephippiocarpa Alston 125 NCES Rendle 307 A
M. farinosa Launert 15 WC Plowes 1878 A
M. macrocarpa C.Presl 5 W Whellan 1664 A
M. minuta L. 124 N J. Burrows 2521 A
M. nubica A.Braun 15 NW Gibbs-Russell 1629 A

SALVINIACEAE

- 413 **Salvinia** Adans.
* *S. molesta* Mitchell 1245 NWCE Mitchell 1330 A
S. auriculata sensu Schelpe

AZOLLACEAE

- 414 **Azolla** Lam.
A. filiculoides Lam. 5 NC J. Burrows 3066 A
A. nilotica Decne. ex Mett. 234 NW Guy 902 A
A. pinnata R.Br. 1245 W Van Someren 87308 A
var. *africana* (Desv.) Bak.

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A REMARKABLE NEW *LEUCOSPERMUM* (PROTEACEAE) FROM THE SOUTHERN CAPE

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ABSTRACT

Leucospermum hamatum Rourke (Proteaceae), a new species from the southern Cape is described, characterised by its minute 4 to 7-flowered inflorescences and re-torsely barbed subterminal region of the style.

UITTREKSEL

'N BESONDERE NUWE *LEUCOSPERMUM* (PROTEACEAE) VANAF DIE SUID-KAAP

Leucospermum hamatum Rourke (Proteaceae), 'n nuwe soort vanaf die Suid-Kaap word beskryf, gekenmerk deur die klein 4-7 blomme in die bloeiwyses en na onder-gerigte weerhake aan die subterminale streek van die styl.

Key words: *Leucospermum*, sp. nov., Proteaceae, southern Cape.

This extraordinary species was discovered in 1978 on the north slopes of the Outeniqua mountains in the southern Cape, by Mr. G. le Roux, forester at Ruitersbos Forest Station. He brought it to the attention of Mr. W. J. Bond of the Saasveld Forest Research Station near George, who in turn submitted herbarium material to me for identification.

As Bond's original collection consisted of largely sterile, vegetative material, it was determined as *Leucospermum secundifolium* Rourke, since the foliage closely resembled that of the latter species. Subsequently however, Mr. J. H. J. Vlok, also of the Saasveld Forest Research Station, queried this identification after obtaining flowering specimens. He thereupon invited me to accompany him on a field excursion to examine the species *in situ* during the height of the flowering season, in August 1982. After examining a population in the field, it was at once apparent that this bizarre species was quite unlike *Leucospermum secundifolium*, and, indeed, bore little resemblance to any other known *Leucospermum* (Rourke, 1972). It is here described as new.

Leucospermum hamatum Rourke, species nova: species nana miranda, a habitu prostrato implexo, foliis secundis, inflorescentiis minutis 4-7 floribus.

Accepted for publication 20th January, 1983.

perianthiis curtis proximalibus inflatis, stylis hamatis retrorsis distalibus et valde adaxialibus arcuatis, distinguitur.

Frutex humilis prostratis; tegetes densae formantes, 1–3 m in diam.; ad 100 mm altae. *Folia* secunda, sparsim puberula, postea glabra; anguste oblonga vel oblonga-elliptica, 45–65 mm longa, 8–18 mm lata; breviter petiolata, petioli ad 5 mm longi; apices plerumque tridentati, aliquando integri. *Inflorescentia* turbinata, 15–20 mm in diam., 4–7 floribus. *Involucrum* redactum ad 3 vel 4 bracteas. *Bracteae* ovatae acuminatae, conduplicatae, 10–15 mm longae, 4–6 mm latae, sparsae puberulae. *Perianthium* 10–14 mm longum, valde adaxile arcuatum, utriculosum et inflatum distale, glabrum sed unguibus marginibus et sinibus fimbriatis. *Stylus* 18–20 mm longus, cygneus, valde adaxilis arcuatus, barbatus retrorsus apicem versus. *Stigma* conica acuta, 20 mm longa.

Typus: Cape Province—3322 (Oudtshoorn): Outeniqua mountains, north slopes of Moordkuils River catchment area on Klein Moeras River Farm (-CC), 24/08/1982, J. P. Rourke 1779 (NBG, holotypus; PRE, K, MO, S, STE, BOL, L, NSW, SAAS, PRF, isotypus).

A prostrate sprawling shrub forming dense mats 1–3 m in diam., up to 100 mm in height with several stout (to 25 mm thick) branches radiating horizontally along ground, from a single stout main trunk up to 45 mm in diam. *Flowering branches* slender, trailing, frequently dichotomous, 2 mm in diam., very sparsely villous, usually bearing a single terminal inflorescence and several axillary inflorescences. *Leaves* second, narrowly oblong to oblong-elliptic, 45–65 mm long, 8–18 mm wide, shortly petiolate, petiole to 5 mm long; apex usually tridentate occasionally entire; sparsely puberulous, later glabrous. *Inflorescence* turbinate, 15–20 mm in diam., consisting of 4 to 7 flowers apparently arranged in a single whorl; pedunculate, peduncle 10–20 mm long. *Involucre* either absent or reduced to 3 or 4 bracts, lanceolate-acute to acuminate, 7–10 mm long, 2–8 mm wide, sparsely puberulous. *Floral bracts* ovate acuminate, conduplicate, tightly clasping the base of the perianth, 10–15 mm long, 4–6 mm wide, sparsely puberulous externally, margins puberulously fimbriate. *Perianth* very strongly adaxially curved, 10–14 mm long; tube utriculose, much inflated and swollen distally to 5 mm in diam., glabrous; claws very reduced and tightly adaxially curved, broad-

FIG. 1.

Leucospermum hamatum, drawn from the type material (Rourke 1779).

(1) flowering shoot; (2) single flower and subtending floral bract; (3) perianth spread open; (4) gynoecium showing style, pollen presenter and hypogynous scales; (5) floral bract; (6) perianth limb and anther; (7) fruit, adaxial view.



ened proximally, tapering distally, the three adaxial perianth segments incompletely fused, 4 mm long, the free abaxial segment 5–6 mm long; outer surface glabrous but margins and the two adaxial sinuses at junction with perianth tube lanately fimbriate; limbs lanceolate-cymbiform, acute, 2 mm long, outer surface granulate-glabrescent. *Anthers* 4, sessile, arising from a prominently swollen cushion of carnose connective. *Style* 18–20 mm long, strongly adaxially cygneous, subterminal region tapered, retrorsely barbed, becoming sparsely granulate basally. *Pollen presenter* conic-acute, 2 mm long, stigmatic groove terminal. *Ovary* not differentiated from style, minutely puberulous 1 mm long. *Hypogynous scales* linear-obtuse, 2 mm long. *Fruit* a minutely puberulous, cylindric, greyish-white achene, broadly emarginate at base.

RELATIONSHIPS AND DIAGNOSTIC CHARACTERS

This species is not obviously allied to any other in the genus, nor can it be accommodated in any existing section within *Leucospermum* (Rourke, 1972). The inflorescence is so reduced as to consist of between four and seven (usually five) flowers, arranged in a radially symmetric manner so as to form an apparent whorl, with the styles of each flower all strongly curved inwards. *Leucospermum hamatum* is probably both the most reduced and the most specialised species in the genus. In each inflorescence the involucre is either absent or reduced to a mere three or four bracts, while the floral bracts subtending each flower are enlarged to form a cup-like “pseudo-involucre” clasping the perianths.

The specific epithet “hamatum” draws attention to a character unique in *Leucospermum* and in fact in the whole of the South African Proteaceae; namely, the presence of minute, retrorsely directed barbs in the subterminal region of the style.

DISTRIBUTION, HABITAT AND BIOLOGY

Leucospermum hamatum is apparently a highly localised endemic. It is presently known from a single site in the catchment area of the Moordkuils River on Klein Moeras River farm in the northern foothills of the Outeniqua mountains. When inspected in August 1982, a population of well over a thousand individuals was found at this locality, dispersed over several hectares at a mean elevation of 750 m. The plants were in various stages of development; some being fully mature, while others were seedlings regenerating after a recent fire. *Leucospermum hamatum* is a seed-regenerator which does not survive burning.

Mature shrubs develop into dense, prostrate, sprawling mats up to 3 m in diameter with numerous horizontally radiating branches arising from a single stout main trunk. Most specimens attain less than 100 mm in height



FIG. 2.
Distribution of *Leucospermum hamatum*.



FIG. 3.
Growth habit showing the prostrate mode of growth.

when fully grown and consequently tend to be rather inconspicuous in the rank surrounding fynbos, where tall, shrubby associates, such as *Leucadendron ericaefolium*, *Berzelia intermedia* and *Erica seriphiifolia* are prominent.

This species was observed in a variety of niches, such as on moist clay derived from the lower Table Mountain Sandstone shaleband, in damp peaty seepage zones, as well as on drier, rocky, well-drained north-facing Table Mountain Sandstone slopes. Normally the foliage is bright green but leaves on new shoots and on those exposed to direct sunlight, tend to be suffused with deep carmine tones.

Flowering takes place over several months, principally between July and November, but as the tiny (15–20 mm in diam.) inflorescences are borne



FIG. 4.

Developing inflorescences on a flowering shoot. The unopened perianths and elongating styles are clasped within an "involucre" formed by the subtending floral bracts.
× 2.

at ground level, often concealed in the dense surrounding fynbos, they are easily overlooked. The inconspicuousness of the inflorescences is heightened by their drab colouration; the perianths are hyaline, the styles pale yellow-amber and the "involucre" of floral bracts is dull carmine. It thus seems unlikely that this species is bird-pollinated or even insect-pollinated, as are the majority of leucospermums (Rourke, 1972).

Pollination by small rodents is, however, a distinct possibility although this supposition is presently based on circumstantial evidence. Nectar wells

up and accumulates in the swollen, bladder-like perianth tubes. In many inflorescences the walls of these inflated perianth tubes were observed to have been gnawed away, presumably to provide access to the nectar reservoirs. A small rodent placing its snout into the centre of each inflorescence would be perfectly positioned so as to gnaw through the inflated perianth tubes and lap the nectar while brushing pollen from the inwardly directed pollen presenters onto its snout.

In almost a third of the recently opened inflorescences, which were examined in the field, the inflated perianth tubes of most of the flowers had been punctured, gnawed (by rodents ?), and the nectar removed in this manner.

SPECIMENS EXAMINED

CAPE PROVINCE—3322 (Oudtshoorn): Outeniquas, Klein Moeras River catchment at foot of steep north slope (-CC), 29/5/1978, *W. J. Bond 1414* (NBG, SAAS); Outeniqua mountains, north slopes of Moordkuils River catchment area on Klein Moeras River farm, 24/8/1982, *J. P. Rourke 1779* (NBG, PRE, K, MO, S, STE, BOL, L, NSW, SAAS, PRF).

ACKNOWLEDGEMENTS

I would like to thank Mr. J. H. J. Vlok and Mr. G. le Roux of the Department of Environment Affairs (Directorate of Forestry) for arranging the field excursion which enabled me to collect and study *Leucospermum hamatum* in its natural habitat. Their enthusiasm and assistance in undertaking this work is gratefully acknowledged.

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THE TAXONOMIC VALUE OF TRICHOMES IN *PELARGONIUM* L'HÉRIT. (GERANIACEAE)

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ABSTRACT

A detailed study of the indumentum of the leaves of 133 *Pelargonium* species led to the classification of the trichomes into 11 different types: six non-glandular and five glandular hair types. The non-glandular hairs are uni- to multicellular and of different lengths, shape and wall thickness. Some hairs have a podium at the base. The glandular hairs consist of a uniserial stalk of various lengths and unicellular head of various shapes. The distribution of the various trichome and indumentum types in the different taxa of *Pelargonium* is discussed, especially where it can be of diagnostic value and serve as possible indication of relationships.

UITTREKSEL

DIÉ TAKSONOMIESE WAARDE VAN TRIGOME IN *PELARGONIUM* L'HÉRIT. (GERANIACEAE)

'n Volledige ondersoek van die indumentum van die blare van 133 *Pelargonium*-spesies het gelei tot die klassifikasie van die trigome in dié genus in 11 tipes: ses haartipes en vyf klierhaartipes. Die hare is een- tot veelsellig en varieer in lengte, vorm en wanddikte. Sommige hare het 'n podium by die basis. Die klierhare bestaan uit 'n uniseriale steel van verskillende lengtes en eensellige kop van verskillende vorme. Die verspreiding van die verskillende trigoom- en indumentumtipes in die verskillende taksa van *Pelargonium* word bespreek, veral waar dit van diagnostiese waarde kan wees en as moontlike aanduiding van verwantskappe kan dien.

Key words: *Pelargonium*, Geraniaceae, trichomes, diagnostic characters.

INTRODUCTION

Trichomes can be studied from two different perspectives: (1) the nature of the individual trichomes themselves, and (2) the characteristics which they collectively impart to the surfaces upon which they occur, i.e. the nature of the indumentum layer as a whole. Since the indumentum is not as

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Accepted for publication 24th January, 1983.

much influenced by the structure of the individual trichomes as by their distribution and density, trichomes of rather different structure may give rise to similar indumentum types. It is also possible that the environment has a greater influence in modifying the indumentum than in changing the type of trichome (Johnson, 1975).

According to Carlquist (1961) trichomes often provide the taxonomist with the most important anatomical characters used in systematic comparisons. This is probably due to their variety, almost universal presence in angiosperms, simple preparation methods for studying, and close resemblance to patterns of variation in classification systems. In a taxonomic trichome study it is necessary to examine the whole trichome complement, and indicate the organographic distribution of the different trichome types as well.

The last comprehensive taxonomic revision of the genus *Pelargonium* was done by Knuth in 1912. It has become clear that his identification keys are unsatisfactory, and that some species are erroneously placed into sections. Since his revision, a number of new species have also been described. The genus includes more than 200 natural species of which the majority occur in southern Africa.

Phillips (1951), Willis (1973) and Van der Walt (1977) mention the fact that *Pelargonium* species are often conspicuously hairy and aromatic, and produce essential oils used in the perfume industry. Because trichome studies have already proved to be of taxonomic value in a number of taxa of various ranks, this study has been carried out as part of the extensive taxonomic project on *Pelargonium* in progress at the University of Stellenbosch.

The purpose of this study was to distinguish between, and classify, different trichome and indumentum types present in the genus, and to determine whether these types can be used as taxonomic characters in distinguishing between taxa, and in the determination of the possible phylogenetic relationships of these taxa.

MATERIAL AND METHODS

The petioles and laminae of 133 species and subspecies of *Pelargonium* were studied. The material was obtained from plants cultivated in the botanic garden of the University of Stellenbosch. In order to describe the type and density of the indumentum, the petioles and laminae were studied with the aid of a dissection microscope. Transverse sections were made of the above-mentioned organs in order to examine the structure of the individual trichomes. The figures presented in this paper are semi-schematic and drawn to scale.

Indumentum types

The following terminology has been used to describe the indumentum types in the different taxa of *Pelargonium*:

ciliated: thin hairs, all of approximately the same length, on the margin of the leaf

fimbriate: long, relatively thick, filamentous hairs on the margin of the leaf

glabrous: without trichomes

glandular: covered with glandular hairs

hirsute: covered with long, straight, stiff hairs (not spiny) (hairs are thinner than in the case of a hispid indumentum)

hirtellous (minutely hirsute): like hirsute, but with shorter hairs

hispid: covered with long, straight, stiff, almost spiny hairs (hairs are thicker than in the case of a hirsute indumentum)

lanate (woolly): covered with long, dense, entangled curly hairs – longer than in the case of a tomentose indumentum, and without a matted appearance

pilose: covered with thin, soft hairs, longer than in the case of a pubescent indumentum

pubescent: covered with short, thin, soft hairs

setose (bristly): covered with very stiff, hard hairs (hairs are thicker and harder than in the case of a hispid indumentum)

strigose: covered with stiff hairs with a sharp point, the hairs being appressed to the surface and orientated in a distal or proximal direction

tomentose (densely woolly): covered with very dense, entangled, short hairs with a matted appearance

velutinous: covered with very dense, straight, short hairs – appears velvety

villous: covered with long, thin, soft hairs – not as dense as a tomentose indumentum, and without a matted appearance.

Density of indumentum

The following terms were used to describe the density of the indumentum (given in descending degree of density):

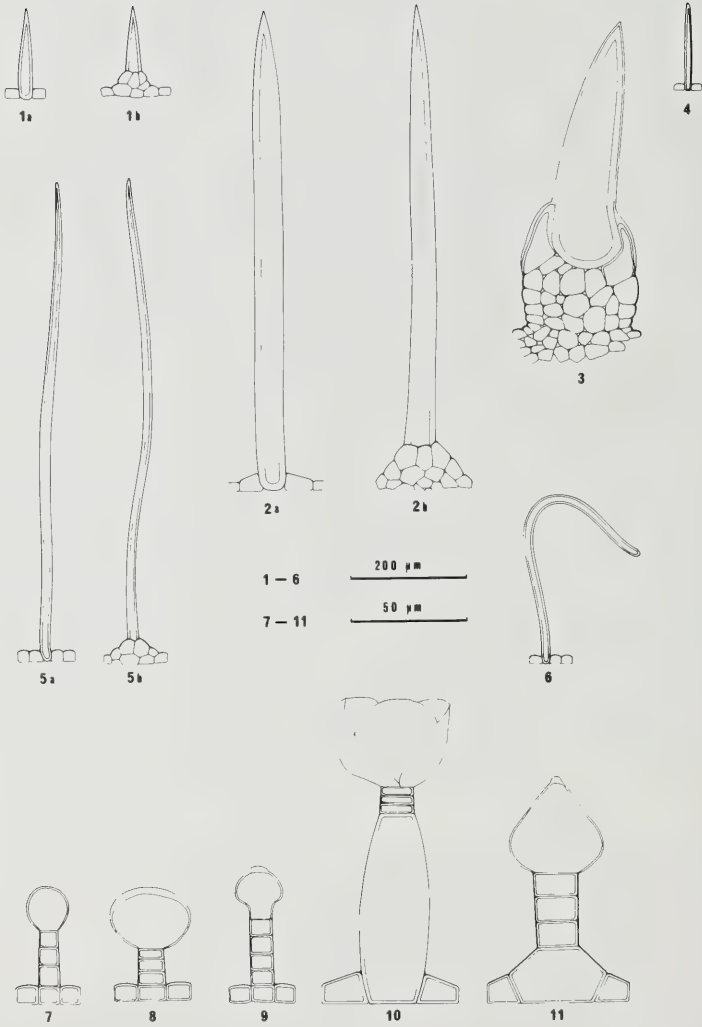
dense (to very dense): epidermal cells are hardly visible

relatively dense: trichomes are abundant

scattered: trichomes are less abundant

sparse (to almost glabrous): trichomes are scarce.

For each of the examined taxa the indumentum type and density were described in detail for the petiole, and ad- and abaxial sides of the lamina.



RESULTS

Trichome types

Only uni- and multicellular non-glandular hairs, and glandular hairs with a uniserial stalk (of various lengths) and unicellular head (of various shapes) occur in *Pelargonium* species. The length, thickness of the wall, shape (straight or curly) and presence of a podium served as criteria to classify the non-glandular hairs. (A podium is a multicellular structure, consisting of epidermal cells which are raised above the rest of the surface, and which surround the hair base, which is sunken into the podium.) With glandular hairs, the length of the stalk and shape of the glandular head and basal cell were used as characters of distinction. Due to the fact that transitional forms also occur, it is often difficult to classify such hairs. Glandular hairs, which are more closely connected to physiological processes in the plant, exhibit greater constancy of characters.

The following trichome types occur in the different taxa of *Pelargonium* (Fig. 1):

Type 1: short, straight, stiff hair; (a) without a podium; (b) with a podium.

Type 2: long, straight, stiff to almost spiny hair; (a) without a podium; (b) with a podium.

Type 3: very stiff, hard hair with a prominent podium.

Type 4: short, thin, soft hair.

Type 5: long, thin, soft hair; (a) without a podium; (b) with a podium.

Type 6: curly hair.

Type 7: short glandular hair with a small globular head, and stalk consisting of two to four cells.

Type 8: short glandular hair with a large globular head, and stalk consisting of one to four cells.

Type 9: short glandular hair with a small bulb-shaped head, and stalk consisting of two to five cells.

Type 10: relatively long to very long glandular hair with a globular or

FIG. 1.

Trichome types occurring in *Pelargonium*. 1: Short, straight, stiff hair (a) without a podium, (b) with a podium. 2: Long, straight, stiff to spiny hair (a) without a podium, (b) with a podium. 3: Very stiff, hard hair with a prominent podium. 4: Short, thin, soft hair. 5: Long, thin, soft hair (a) without a podium, (b) with a podium. 6: Curly hair. 7: Short glandular hair with a small globular head, and stalk consisting of two to four cells. 8: Short glandular hair with a large globular head, and stalk consisting of one to four cells. 9: Short glandular hair with a small bulb-shaped head and stalk consisting of two to five cells. 10: Relatively long to very long glandular hair without a globular or bulb-shaped head, and stalk consisting of three to numerous cells of which the basal one is always elongated and often swollen. 11: Short glandular hair with a large pear-shaped head.

bulb-shaped head, and stalk consisting of three to numerous cells of which the basal one is always elongated and often swollen.

Type 11: short glandular hair with a large pear-shaped head.

A total of 11 trichome types have thus been distinguished: types 1 to 6 are non-glandular hair types, and 7 to 11 glandular hair types. Types 1, 2 and 4 have been subdivided on the ground of the presence of a podium surrounding the hair base. In many cases the sculpture of the hair surface also varies: a scanning electron microscopic study may therefore lead to a more detailed classification of trichome types.

Table 1 represents the occurrence of the different trichome types on the lamina and petiole of 133 taxa of *Pelargonium*. In the columns the trichome types are represented by their numbers (1 to 11) as indicated in Fig. 1. Every row contains the trichome types of a single species. The table is presented as illustration of how taxonomic conclusions could be drawn from this trichome study.

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TABLE 1

Occurrence of trichomes on the petiole and lamina of species of *Pelargonium*. Trichome numbers refer to the types as indicated in Fig. 1. Unidentified species have been given a project number, and are referred to as *P.* species (project number x).

Species	Petiole													
	Non-Glandular Hairs									Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
Hoarea														
P. auritum														
-subsp. auritum	*	*		*						*				
-subsp. carneum	*	*		*						*				
P. carneum	*			*						*				
P. incrassatum				*		*				*			*	
P. oblongatum				*		*	*	*		*			*	
P. pinnatum	*			*						*			*	
P. punctatum	*			*						*			*	
P. rapaceum	*	*		*						*			*	
P. spathulatum														
P. species (1571)	*	*		*						*			*	
P. species (2587)	*	*		*						*			*	
P. species (1613)				*						*			*	
P. species (442)				*						*			*	
P. species (2440)	*		*	*						*			*	
P. species (1456)				*						*			*	
P. species (1653)	*		*							*				
P. species (2439)	*			*						*			*	
P. species (2443)	*			*						*				
P. species (1454)	*	*								*				
Section														
Seymouria														
P. asarifolium			*			*	*			*	*			
P. dipetalum				*						*				
P. marginatum				*						*				
P. trifoliatum	*			*						*				

Species	Lamina													
	Non-Glandular Hairs									Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
<i>Hoarea</i>														
<i>P. auritum</i>														
-subsp. <i>auritum</i>				*						*	*		*	
-subsp. <i>carneum</i>				*						*	*			
<i>P. carneum</i>				*						*				
<i>P. incrassatum</i>				*		*	*			*	*		*	
<i>P. oblongatum</i>						*	*			*			*	
<i>P. pinnatum</i>		*		*						*			*	
<i>P. punctatum</i>	*			*						*			*	
<i>P. rapaceum</i>			*	*						*	*			
<i>P. spathulatum</i>			*							*				
<i>P. species (1571)</i>	*		*							*			*	
<i>P. species (2587)</i>			*	*						*				
<i>P. species (1613)</i>			*							*			*	
<i>P. species (442)</i>			*							*				
<i>P. species (2440)</i>			*							*			*	
<i>P. species (1456)</i>			*							*			*	
<i>P. species (1653)</i>	*		*							*				
<i>P. species (2439)</i>			*							*	*		*	
<i>P. species (2443)</i>			*							*			*	
<i>P. species (1454)</i>			*							*			*	
Section														
<i>Seymouria</i>														
<i>P. asarifolium</i>									*	*	*			
<i>P. dipetalum</i>			*							*				
<i>P. marginatum</i>				*						*	*			
<i>P. trifoliatum</i>			*	*							*			

Species	Petiole														
	Non-Glandular Hairs										Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11	
Section:															
<i>Polyactium</i>															
<i>P. anethifolium</i>	*									*					
<i>P. bowkeri</i>	*											*	*		
<i>P. caffrum</i>						*		*		*					
<i>P. flabellifolium</i>		*		*						*			*		
<i>P. heracleifolium</i>						*				*	*				
<i>P. lobatum</i>															
<i>P. luridum</i>		*		*						*			*		
<i>P. multiradiatum</i>	*	*								*					
<i>P. pillansii</i>	*			*						*					
<i>P. pulverulentum</i>										*					
<i>P. radulaefolium</i>						*	*			*		*	*		
<i>P. schizopetalum</i>			*	*						*		*	*		
<i>P. triste</i>				*						*			*		
<i>P. woodii</i>		*		*						*		*	*		
Section:															
<i>Otidia</i>															
<i>P. alternans</i>			*							*					
<i>P. carnosum</i>	*									*					
<i>P. ceratophyllum</i>	*									*					
<i>P. crithmifolium</i>	*									*					
<i>P. dasyphyllum</i>	*									*					

Species	Lamina													
	Non-Glandular Hairs									Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
<i>Polyactium</i>														
<i>P. anethifolium</i>										*				
<i>P. bowkeri</i>	*		*							*			*	
<i>P. caffrum</i>							*			*				
<i>P. flabellifolium</i>				*						*			*	
<i>P. heracleifolium</i>			*							*	*	*		
<i>P. lobatum</i>	*	*			*					*				
<i>P. luridum</i>				*						*			*	
<i>P. multiradiatum</i>	*			*						*				
<i>P. pillansii</i>				*						*				
<i>P. pulverulentum</i>										*	*			
<i>P. radulaefolium</i>							*	*		*			*	
<i>P. schizopetalum</i>			*							*			*	
<i>P. triste</i>			*	*						*			*	
<i>P. woodii</i>			*							*			*	
Section:														
<i>Otidia</i>														
<i>P. alternans</i>			*	*						*				
<i>P. carnosum</i>			*	*						*			*	
<i>P. ceratophyllum</i>	*									*				
<i>P. crithmifolium</i>			*							*				
<i>P. dasyphyllum</i>	*									*				

Species	Petiole														
	Non-Glandular Hairs									Glandular Hairs					
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11	
Section:															
<i>Ligularia</i>															
<i>P. abrotanifolium</i>						*					*		*		
<i>P. aridum</i>							*			*	*				
<i>P. artemisiaefolium</i>	*				*					*	*				
<i>P. articulatum</i>		*			*					*	*				
<i>P. dolomiticum</i>							*	*		*			*		
<i>P. exstipulatum</i>						*					*				
<i>P. fragile</i>	*				*					*				*	
<i>P. grandicalcaratum</i>	*						*			*					
<i>P. hirtum</i>				*		*	*			*					
<i>P. hystrix</i>				*						*			*		
<i>P. ionidiflorum</i>				*		*				*			*		
<i>P. karooicum</i>	*									*	*				
<i>P. oreophilum</i>	*			*						*			*		
<i>P. ovato-stipulatum</i>					*					*		*	*		
<i>P. praemorsum</i>				*		*				*	*		*		
<i>P. pulchellum</i>				*		*				*			*		
<i>P. ramosissimum</i>	*				*			*		*				*	
<i>P. sericifolium</i>			*							*	*				
<i>P. xerophyton</i>	*									*	*				
Section:															
<i>Jenkinsonia</i>															
<i>P. antidysentericum</i>	*						*					*	*	*	
<i>P. tetragonum</i>	*									*					

Species	Lamina													
	Non-Glandular Hairs							Glandular Hairs						
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
<i>Ligularia</i>														
<i>P. abrotanifolium</i>						*					*		*	
<i>P. aridum</i>				*						*				
<i>P. artemisiaefolium</i>				*	*					*				
<i>P. articulatum</i>					*					*				
<i>P. dolomiticum</i>	*				*	*	*			*			*	
<i>P. exstipulatum</i>						*					*			
<i>P. fragile</i>	*				*					*				*
<i>P. grandicalcaratum</i>			*							*	*			
<i>P. hirtum</i>	*			*						*				
<i>P. hystrix</i>				*						*			*	
<i>P. ionidiflorum</i>	*			*						*			*	
<i>P. karooicum</i>			*							*	*			
<i>P. oreophilum</i>	*			*						*	*		*	
<i>P. ovato-stipulatum</i>	*									*	*		*	
<i>P. praemorsum</i>	*									*	*			
<i>P. pulchellum</i>			*			*				*			*	
<i>P. ramosissimum</i>					*					*				*
<i>P. sericifolium</i>			*							*				
<i>P. xerophyton</i>	*									*				
Section:														
<i>Jenkinsonia</i>														
<i>P. antidysentericum</i>	*			*								*	*	*
<i>P. tetragonum</i>	*	*								*				

Species	Petiole													
	Non-Glandular Hairs									Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
<i>Myrrhidium</i>														
<i>P. candicans</i>	*	*			*			*		*				
<i>P. longicaule</i>														
-subsp. <i>angusti-</i>														
<i>petalum</i>	*			*						*				
-subsp. <i>caucali-</i>														
<i>folium</i>	*							*		*				
-subsp. <i>convol-</i>														
<i>vulifolium</i>	*		*							*				
-subsp. <i>longicaule</i>	*									*		*		
<i>P. multicaule</i>														
-subsp. <i>trian-</i>														
<i>gulare</i>	*	*					*			*				
<i>P. myrrhifolium</i>														
-subsp. <i>coriandri-</i>														
<i>folium</i>	*	*		*						*				
-subsp. <i>myrrhi-</i>														
<i>folium</i>	*	*		*	*					*				*
<i>P. suburbanum</i>														
-subsp. <i>bipinnati-</i>														
<i>fidum</i>							*		*	*				
-subsp. <i>suburba-</i>														
<i>num</i>									*	*				
Section:														
<i>Peristera</i>														
<i>P. chamaedrifolium</i>	*									*				
<i>P. fumaroides</i>	*									*				
<i>P. grossularoides</i>										*				
<i>P. harveyanum</i>	*			*						*			*	
<i>P. iocastum</i>	*									*				

Species	Lamina													
	Non-Glandular Hairs									Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
Myrrhidium														
P. candicans			*							*				
P. longicaule														
-subsp. angustipetalum	*			*						*				
-subsp. caucali- folium	*									*				
-subsp. convol- vulifolium	*		*							*				
-subsp. longicaule	*									*				
P. multicaule														
-subsp. trian- gulare	*	*					*			*				
P. myrrhifolium														
-subsp. coriandri- folium	*	*			*					*				
-subsp. myrrhi- folium	*	*			*					*				*
P. suburbanum														
-subsp. bipinnati- fidum	*		*		*		*		*	*				
-subsp. suburba- num	*			*					*	*				
Section:														
Peristera														
P. chamaedrifolium	*									*				
P. fumaroides	*									*				
P. grossularoides	*									*				
P. harveyanum	*			*						*			*	
P. iocastum	*		*							*				

Species	Petiole													
	Non-Glandular Hairs									Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
<i>Campylia</i>														
<i>P. caespitosum</i>														
-subsp. <i>caespitosum</i>						*				*	*		*	
-subsp. <i>concavum</i>	*									*				
<i>P. capillare</i>			*	*						*				
<i>P. coronopifolium</i>														
-subsp. <i>angustissimum</i>	*									*				
-subsp. <i>coronopifolium</i>	*									*				
<i>P. elegans</i>	*			*						*				
<i>P. oenotherae</i>	*		*	*						*				
<i>P. ovale</i>	*		*							*				
<i>P. tricolor</i>	*		*							*				
Section:														
<i>Dibrachya</i>														
<i>P. lateripes</i>				*			*			*				
<i>P. peltatum</i>			*				*			*				
Section:														
<i>Eumorpha</i>														
<i>P. alchemilloides</i>			*							*				
<i>P. elongatum</i>				*	*		*			*			*	
<i>P. grandiflorum</i>					*					*				
<i>P. patulum</i>	*				*					*				
<i>P. quinquelobatum</i>				*						*				
<i>P. tabulare</i>	*				*					*				
<i>P. transvaalense</i>							*			*			*	

Species	Lamina													
	Non-Glandular Hairs									Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
<i>Campylia</i>														
<i>P. caespitosum</i>														
-subsp. <i>caespitosum</i>			*								*		*	
-subsp. <i>concavum</i>	*									*				
<i>P. capillare</i>			*	*						*				
<i>P. coronopifolium</i>														
-subsp. <i>angustissimum</i>	*										*			
-subsp. <i>coronopifolium</i>	*										*			
<i>P. elegans</i>	*			*						*				
<i>P. oenotherae</i>		*	*							*		*		
<i>P. ovale</i>	*									*				
<i>P. tricolor</i>	*	*								*				
Section:														
<i>Dibrachya</i>														
<i>P. lateripes</i>	*													
<i>P. peltatum</i>			*							*				
Section:														
<i>Eumorpha</i>														
<i>P. alchemilloides</i>			*	*						*				
<i>P. elongatum</i>			*		*					*				
<i>P. grandiflorum</i>	*													
<i>P. patulum</i>	*				*					*				
<i>P. quinquelobatum</i>				*						*				
<i>P. tabulare</i>	*				*					*				
<i>P. transvaalense</i>			*							*				

Species	Petiole													
	Non-Glandular Hairs										Glandular Hairs			
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
<i>Glaucophyllum</i>														
<i>P. laevigatum</i>					*									
<i>P. lanceolatum</i>					*									
<i>P. otaviense</i>										*	*			
<i>P. spinosum</i>										*	*			
<i>P. ternatum</i>	*				*					*				
Section:														
<i>Ciconium</i>														
<i>P. acetosum</i>							*			*			*	
<i>P. acraeum</i>			*	*						*			*	
<i>P. frutetorum</i>			*				*			*			*	
<i>P. inquinans</i>			*	*						*			*	
<i>P. zonale</i>	*									*			*	
Section:														
<i>Cortusina</i>														
<i>P. alpinum</i>						*	*			*			*	
<i>P. cradockense</i>						*				*				
<i>P. crassicaule</i>						*				*				
<i>P. cortusaefolium</i>						*	*	*	*		*		*	
<i>P. odoratissimum</i>						*	*			*			*	
<i>P. magenteum</i>						*	*			*				
<i>P. sidaefolium</i>						*				*				

Species	Lamina														
	Non-Glandular Hairs										Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11	
Section:															
<i>Glaucophyllum</i>															
<i>P. laevigatum</i>					*					*					
<i>P. lanceolatum</i>					*										
<i>P. otaviense</i>											*				
<i>P. spinosum</i>										*	*				
<i>P. ternatum</i>	*				*					*					
Section:															
<i>Ciconium</i>															
<i>P. acetosum</i>										*					
<i>P. acraeum</i>							*	*		*					
<i>P. frutetorum</i>			*	*						*			*		
<i>P. inquinans</i>			*							*			*		
<i>P. zonale</i>	*		*							*					
Section:															
<i>Cortusina</i>															
<i>P. alpinum</i>				*		*	*			*					
<i>P. cradockense</i>						*			*	*					
<i>P. crassicaule</i>			*							*					
<i>P. cortusaefolium</i>			*					*	*	*			*		
<i>P. odoratissimum</i>						*				*			*		
<i>P. magenteum</i>							*		*	*					
<i>P. sidaefolium</i>						*			*	*					

Species	Petiole													
	Non-Glandular Hairs									Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
<i>Pelargonium</i>														
<i>P. englerianum</i>	*			*						*	*		*	
<i>P. betulinum</i>	*									*			*	
<i>P. capitatum</i>							*	*		*			*	
<i>P. cordifolium</i>	*						*			*		*	*	
<i>P. crispum</i>	*		*	*						*			*	
<i>P. cucullatum</i>	*					*	*		*	*		*	*	
<i>P. denticulatum</i>					*	*				*	*		*	
<i>P. glutinosum</i>					*						*			
<i>P. hermanniae-</i> <i>folium</i>	*				*					*				
<i>P. hispidum</i>	*		*	*					*	*			*	
<i>P. papilionaceum</i>				*					*	*			*	
<i>P. quercifolium</i>	*			*		*	*		*	*			*	
<i>P. radens</i>	*	*			*					*			*	
<i>P. ribifolium</i>	*	*								*			*	
<i>P. scabroide</i>				*	*					*				
<i>P. scabrum</i>	*			*	*					*	*		*	
<i>P. semitrilobum</i>	*			*						*			*	
<i>P. sublignosum</i>	*				*					*			*	
<i>P. tomentosum</i>			*	*						*			*	
<i>P. vitifolium</i>						*	*	*		*			*	

Species	Lamina													
	Non-Glandular Hairs									Glandular Hairs				
	1a	1b	2a	2b	3	4	5a	5b	6	7	8	9	10	11
Section:														
<i>Pelargonium</i>														
<i>P. englerianum</i>	*				*					*	*		*	
<i>P. betulinum</i>	*	*			*					*				
<i>P. capitatum</i>			*	*			*	*		*		*	*	
<i>P. cordifolium</i>	*									*				
<i>P. crispum</i>	*				*					*	*		*	
<i>P. cucullatum</i>	*						*			*		*	*	
<i>P. denticulatum</i>					*						*		*	
<i>P. glutinosum</i>					*						*			
<i>P. hermanniae-</i> <i>folium</i>	*				*					*				
<i>P. hispidum</i>	*		*	*						*	*		*	
<i>P. papilionaceum</i>				*						*		*	*	
<i>P. quercifolium</i>	*			*		*	*	*		*			*	
<i>P. radens</i>	*				*					*	*		*	
<i>P. ribifolium</i>	*	*								*			*	
<i>P. scabroide</i>					*					*				
<i>P. scabrum</i>		*			*					*	*		*	
<i>P. semitrilobum</i>	*									*				
<i>P. sublignosum</i>		*			*					*	*		*	
<i>P. tomentosum</i>	*			*			*		*	*			*	
<i>P. vitifolium</i>			*	*			*	*		*		*	*	

DISCUSSION

In the genus *Pelargonium* the indumentum of the leaves is generally of a hirsute to hispid type, with a pilose covering relatively rare and woolliness occurring only in some taxa. Glandular hairs are mostly small, with long glandular hairs occurring more prominently in certain sections. In some cases a specific trichome type is present only in a few species of a section. In such cases it can be used to distinguish between species, e.g. *P. suburbanum* is the only species with curly hairs in the section *Myrrhidium*.

If a specific indumentum type occurs in most of the species of a section, that indumentum type can be regarded as characteristic of the section; e.g., the petioles and laminae of species in the section *Hoarea* are mostly strigose, those in the sections *Pelargonium*, *Glaucophyllum* and *Eumorpha* hispid to setose, in the section *Cortusina* pilose and in the section *Otidia* the indumentum is generally sericeous.

Long glandular hairs occur especially in the sections *Hoarea*, *Ciconium*, *Pelargonium* and *Polyactium*, and are lacking in the sections *Seymouria*,

Oidia (except *P. carnosum* (L.) L'Hérit.), *Myrrhidium*, *Peristera* (except *P. harveyanum* Schltr. ex Knuth), *Dibrachya* and *Glaucophyllum*. Glandular hairs with pear-shaped heads occur in the sections *Ligularia*, *Jenkinsonia* and *Myrrhidium*. Glandular hairs are completely absent on the leaves of *P. laevigatum* (L.f.) Willd. and *P. lancolatum* (Cav.) Kern. (section *Glaucophyllum*), *P. grandiflorum* (Andr.) Willd. (section *Eumorpha*) and *P. lateripes* L'Hérit. (section *Dibrachya*). In some species of the sections *Polyactium*, *Peristera* and *Glaucophyllum* non-glandular hairs are completely absent and only glandular hairs occur in these cases. In the section *Glaucophyllum* the indumentum type is very conspicuous with only small glandular hairs and characteristic stiff, spiny to bristly non-glandular hairs present. In some species of especially the sections *Polyactium*, *Dibrachya*, *Eumorpha* and *Glaucophyllum*, as well as *P. tetragonum* (L.f.) L'Hérit. (section *Jenkinsonia*) and *P. spathulatum* (And.) DC. (section *Hoarea*), the lamina and/or petiole is glabrous or nearly so. In some sections, i.e. *Polyactium*, *Ligularia*, *Dibrachya*, *Eumorpha*, *Ciconium* and *Pelargonium* the indumentum occurs only, or more densely, in the adaxial groove of the petiole.

CONCLUSIONS

Due to the fact that in every species the trichome complement consists of a number of characteristic trichome types, and that specific trichome types occur only in certain sections, while in the different species and subspecies of each section the trichomes themselves also differ, trichomes can be of taxonomic value on section, specific and infra-specific level in the genus *Pelargonium*.

Despite the interspecific variation in trichome density, the indumentum type is often characteristic of specific sections (vide DISCUSSION). In the sections the trichome complement consists of certain combinations of trichome types which differ from the combinations found in other sections (Table 1). Within the sections species can also often be grouped together according to their trichome complement. This is probably an indication of a close relationship among these species. In the section *Myrrhidium*, for example, the difference between *P. longicaule* Jacq., *P. myrrhifolium* (L.) L'Hérit. and *P. suburbanum* Clifford, and the interrelationship of their subspecies are clearly reflected in the similar trichome complement of the subspecies of every species. The restriction of glandular hairs with pear-shaped heads to the sections *Ligularia*, *Jenkinsonia* and *Myrrhidium* confirms the presumed relationship of these sections.

The occurrence of a specific trichome type on one organ does not necessarily imply that it occurs on the other organs. The glandular hairs with pear-shaped heads were found on both the petiole and lamina of only

P. ramosissimum (Cav.) Willd. and *P. fragile* (Andr.) Willd. (section *Ligularia*), *P. antidysentericum* (Eckl. & Zeyh.) Kostel. (section *Jenkinsonia*) and *P. myrrhifolium* (L.) L'Hérit. subspecies *myrrhifolium* (section *Myrrhidium*). According to Marais (1980) however, this trichome type occurs on the floral parts of all species in the sections *Jenkinsonia* and *Myrrhidium*, and in the case of *P. tetragonum* (L.f.) L'Hérit. (section *Jenkinsonia*), where it does not occur on the leaf, it is mentioned by Fourie (1978) that this type occurs on the stem.

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**A NEW SPECIES OF *BOOPHANE* HERBERT (AMARYLLIDACEAE)
FROM THE NORTH WESTERN CAPE**

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ABSTRACT

A new yellow-flowered species of *Boophane* from the north western Cape, is described and illustrated.

UITTREKSEL

'N NUWE SOORT *BOOPHANE* HERBERT (AMARYLLIDACEAE) VANAF
DIE NOORDWESTELIKE-KAAP

'n Nuwe *Boophane*-spesie met geel blomme uit die noordwestelike Kaapprovinsie word beskryf en geïllustreer.

Key words: *Boophane*, sp. nov., Amaryllidaceae, north western Cape.

Boophane is a small genus of the Amaryllidaceae distributed throughout eastern and southern Africa. In the *Flora Capensis* (1896) Baker recognised three species. Two additional species, *B. haemanthoides* Leighton and *B. pulchra* Barker, both from the western Cape, were described in 1947 and 1963 respectively. At the time of their publication Leighton and Barker collected several more specimens of *Boophane* from Namaqualand, unlike any thus far known. To these specimens (at Kew and the Compton Herbarium) Miss Barker appended the unpublished name *B. flava*.

Field work in Namaqualand during the past three years yielded confirmation of the distinctiveness of *B. flava*. The species is described here for the first time.

***Boophane flava* Barker ex Snijman, sp. nov.**

Boophane flava Barker ex Snijman; species floribus flavis et staminibus declinatis congeneribus diversa.

Bulbus profunde hypogaeus, anguste ad late ovatus, 100-130 mm diam., tunicis crustaceis ferrugineis, superne in collum productis; collum transverse

Accepted for publication 21st February, 1983.

porcatus. *Folia* (3-)4-6, hysteronantha, prostrata, laminis late loratis, 210-420 mm longa, 50-110 mm lata, plana, subtus rubropunctata, margine ciliato. *Pedunculus* complanatus, 200-280 mm longus, 20-50 mm latus, pallidus flavovirens. *Spathae valvae* 2, oblongae, mox marcescens. *Umbella* globosa, 200-400 mm lata. *Flores* 40-220, parvi, flavi, ferrugineis apice. *Pedicili* rigidi, 70-200 mm longi, trigoni. *Perianthium* tubo 1-2 mm longo, segmentis lanceolatis reflexis 9-14 mm longis et 2 mm latis, undulatis prope basin. *Filamenta* declinata, 8-12 mm longa, tumore basi, marronina apicem versus. *Anthera* 2 mm longa, marronina. *Ovarium* trigonum, 3 mm latum, viridis, demum rubescens. *Stylus* plus minusve rectus, 5-8 mm longus. *Capsula* trigona, membranacea, fere 10 mm lata. *Semina* globosa carnosia, fere 5 mm diam.

Type: South Africa, Cape Province, 20 km south of Karkams, fl. 17/4/1981, leaves ex hort. Kirstenbosch 9/9/1981, *Snijman* 438 (NBG, holotype; K, PRE, isotypes). **Figs 2 & 3.**

Bulb deep seated, narrowly to broadly ovate, 100-130 mm diam.; outer tunics hard and brittle, rust-coloured, splitting ultimately into numerous vertical segments with raised transverse bands forming a neck. *Leaves* (3-)4-6, appearing after the inflorescence, recurved and spreading, finally prostrate; blade broadly lorate, 210-420 mm long, 50-110 mm broad, flat, light green, leathery; abaxial surface marked with fine angular red speckles; margin with a white to rusty, soft or chaffy fringe. *Peduncle* flattened, 200-280 mm long, 20-50 mm across greatest diam., pale yellowish-green, glabrous. *Spathe valves* 2, oblong, 40-75 mm long, 20-50 mm wide, yellowish-green, soon becoming withered and reflexed. *Umbel* large, globose, 200-400 mm across. *Flowers* 40-220, small, pale yellow, becoming light brown at the tips. *Pedicels* rigid, 70-200 mm long, ageing to pale maroon, trigonous. *Perianth* tube 1-2 mm long; segments reflexed, lanceolate, 9-14 mm long, 2 mm wide, usually undulate near the base; tips acute. *Filaments* declinate, 8-12 mm, with a large swelling at the base, yellow basally, maroon distally. *Anthers* 2 mm long when open, maroon with yellow pollen. *Ovary* trigonous, 3 mm across, dark green to reddish. *Style* more or less straight, about 5-8 mm long, yellowish. *Capsule* trigonous, membranous, about 10 mm across. *Seeds* globose, fleshy, about 5 mm diam.

Flowering time: March to May.

Leafing period: from May until September.

Distribution: from Komaggas in the north, through Namaqualand to the Bokkeveldberge and the Gifberge in the south, at elevations ranging from 475 to 750 metres above sea level. The species favours flat terrain but shows no substrate preference. In the north the soils are coarse and granitic and

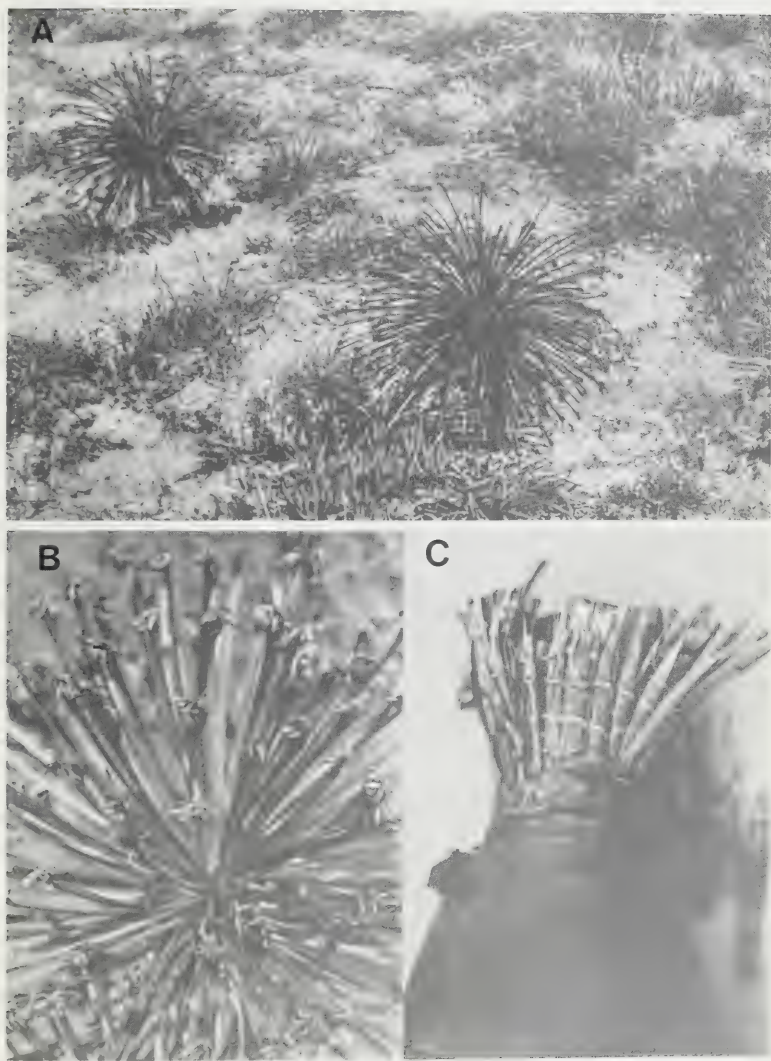


FIG. 1.

A: *Boophane flava* Barker ex Snijman, growing in Namaqualand Broken Veld near Karkams; B: detail of inflorescence; C: detail of bulb showing transversely thickened bands on neck.

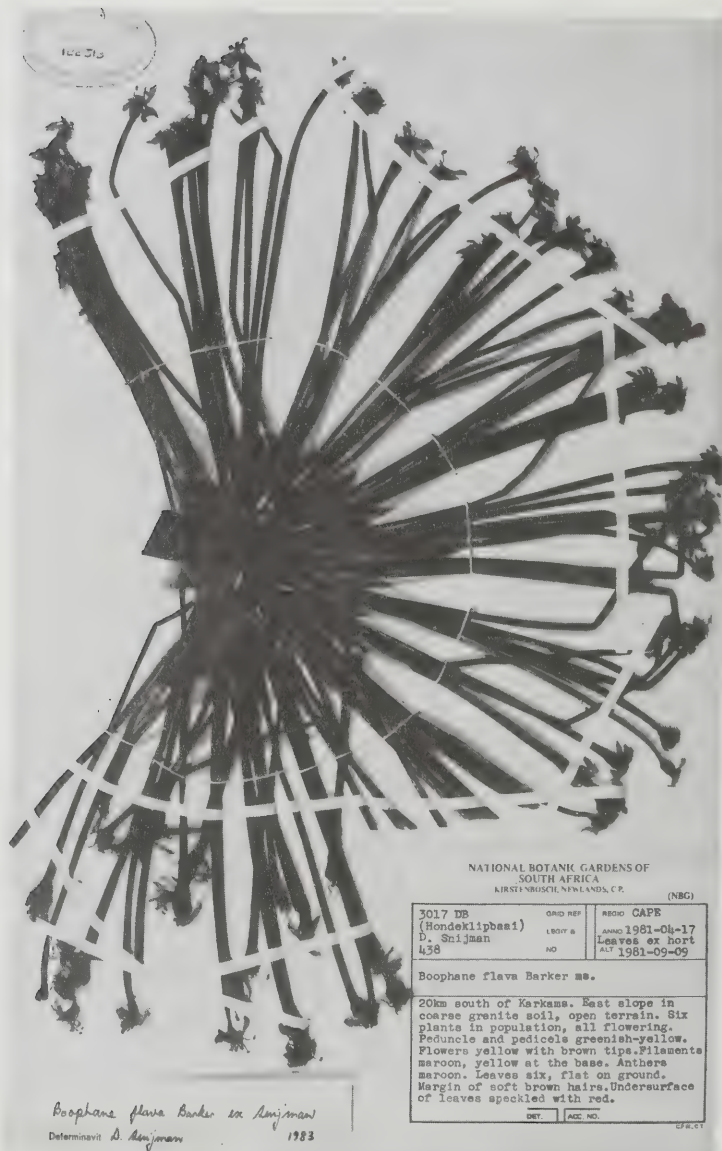


FIG. 2.

Type collection of *Boophane flava* Barker ex Snijman with inflorescence in Compton Herbarium.

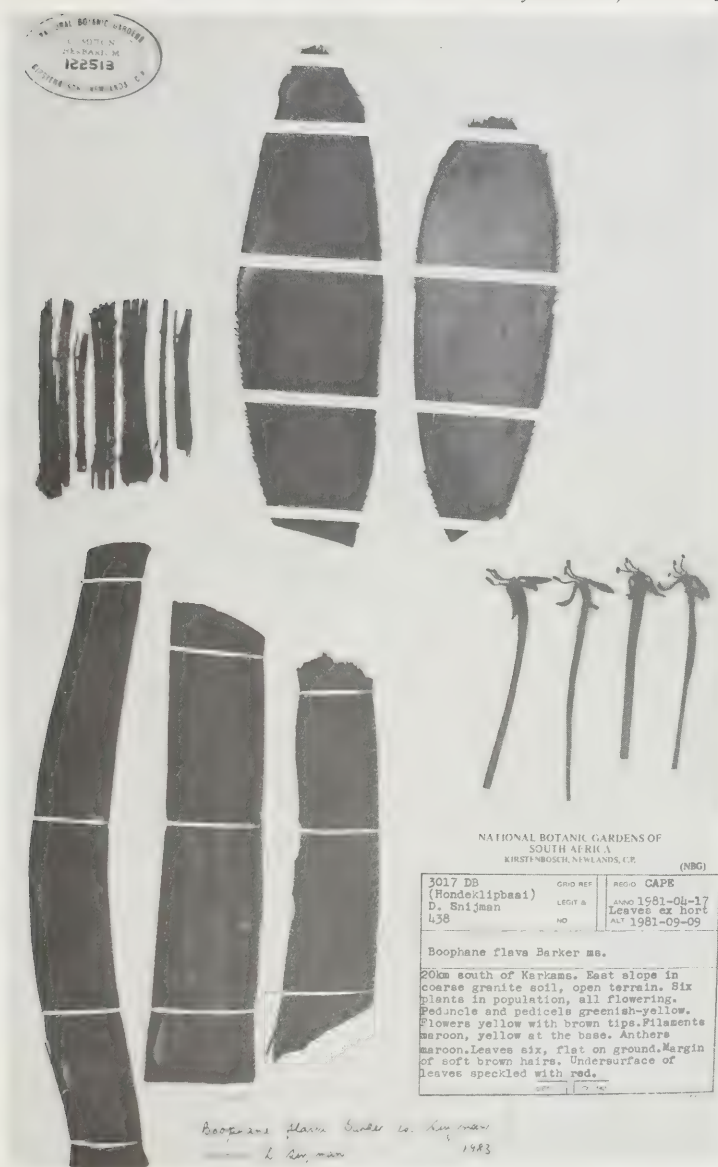


FIG. 3.

Type collection of *Boophane flava* Barker ex Snijman with leaves, peduncles, neck fibres and floral parts in Compton Herbarium.

the cover is mostly of low succulent bushes. On the Bokkeveldberge the soils are heavy clays, whereas in the south the species grows in deep sand of Table Mountain Sandstone origin in association with arid fynbos. Populations are localised made up of more or less ten scattered individuals (Fig. 4).

Boophane flava is most distinctive. Unlike any other species of *Boophane*

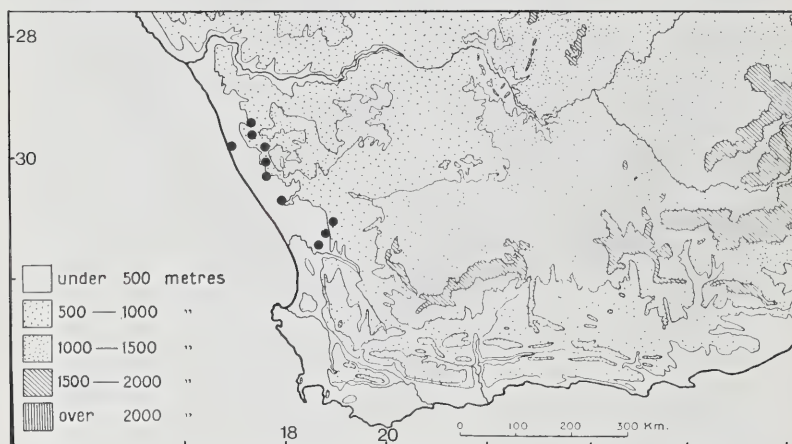


FIG. 4.
Distribution of *Boophane flava* Barker ex Snijman.

it has small yellow flowers with declinate stamens and a bulb with a well-developed neck made up of frayed vertical segments with transversely thickened bands. *Boophane guttata* (L.) Herbert, previously known as *B. ciliaris* (L.) Herbert from the south western Cape, is its closest ally. The latter also has prostrate ciliate leaves and small flowers but differs in that the flowers are actinomorphic and maroon-coloured.

Bulbs of *B. flava* in cultivation at Kirstenbosch for the past eight years have never flowered. The habit of flowering irregularly and sometimes only after long intervals, seems to apply to bulbs in nature as well. The good autumn rain of 1981 caused *B. flava* to flower profusely in the Grootvlei and Kamieskroon areas, sometimes even in private gardens where previously the flowers had never been seen.

The flowers are mostly without a scent but produce copious nectar. During the day ants, bees and butterflies were seen visiting the flowers of which the bees appeared to be the only effective pollinators. The pale yellowish-green colour of the inflorescences made them appear most conspicuous at dusk when the flowers may also be visited by moths.

CAPE—2917 (Springbok): near Van Reenen se Water, Kamaggas 200 (-DA), *van Berkel* 371 (NBG); Komaggas (-DC), *Herre* 1811 (BOL).

—3017 (Hondekliptaai): Schulpfontein (-AA), *van Berkel* 403 (NBG); Grootvlei (-BB), *Leighton* sub NBG 265/45 (NBG), *Snijman* 440 (NBG, PRE), *van Berkel* 319 (NBG); farm Brakdam (-BD), *Snijman* 439 (K, MO, NBG, PRE); just north of Darter's Grave, *Snijman* 604 (NBG, PRE); Kharkams, *Barker* 9869 (K, NBG); 20 km south of Karkams (-DB), *Snijman* 438 (K, NBG, PRE).

—3118 (Vanrhynsdorp): farm Koelfontein, south of Rietpoort (-AA), *Snijman* 705 (NBG); top of Koebee Pass (-DB), *Perry* 1552 (NBG); Gifberg Plateau (-DC), *W. Olivier* 192 (NBG); Giftberg, *Herre* sub SUG 67 (BOL).

—3119 (Calvinia): farm Glen Lyon, east of Nieuwoudtville (-AC), *Snijman* 602 (NBG).

ACKNOWLEDGMENTS

I am sincerely grateful to Nicky and Fred van Berkel for so freely sharing their knowledge of Namaqualand; to my parents for their invaluable assistance with the gathering of the deeply lodged bulbs and to Graham Duncan for his ever-willing help with cultivating the bulbs.

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NOTES ON *TULBAGHIA*: 5. SCANNING ELECTRON MICROSCOPY OF SEED-COAT PATTERNS IN NINETEEN SPECIES*

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ABSTRACT

Scanning Electron Microscopy analysis of seed-coat patterns of nineteen species of *Tulbaghia* has revealed specific differences between them. The differences include variation in the size, form and sculpturing of the seed-coat surface cells. Each species possesses its own constant micro-morphological characteristics which can be used as an additional taxonomic marker.

UITTREKSEL

AANTEKENINGE OOR *TULBAGHIA*: 5. SKANDEER-ELEKTRONMIKROSKOOP ONDERSOEK VAN DIE PATRONE OP DIE SAADHUID VAN NEGENTIEN SOORTE

Skandeer-elektronmikroskoop ondersoek van saadhuid patrone van negentien *Tulbaghia*-soorte het spesifieke verskille aan die lig gebring. Die verskille sluit variasie in grootte, vorm van die oppervlakkige saadhuid-selle in. Elke soort het konstante mikro-morfologiese kenmerke wat as bykomende taksonomiese merker gebruik kan word.

Key Words: *Tulbaghia*. Scanning Electron Microscopy, testa micro-morphology.

INTRODUCTION

Most *Tulbaghia* species are notoriously difficult to identify as herbarium specimens (Vosa, 1975; Burbidge, 1978). Certain fine details of morphology, such as the fleshiness of the corona, are usually poorly preserved in dried material. However, ripe seeds are sometimes found on herbarium specimens and with this in mind, the present study concerns the use of Scanning Electron Microscopy of the seed-coat of *Tulbaghia* species. It includes all the species recognized by Vosa (1975) with the exception of *T. cameroni* Bak. and *T. rhodesica* Fries, for which no adequate seed samples were available.

MATERIAL AND METHODS

Ripe seed samples were collected from correctly identified species both on living plants and on herbarium specimens. Seeds from three to five

* Continued from Jl S. Afr. Bot. 45: 127-132 (1979); 46: 109-114 (1980); 47: 57-61 (1981); 48: 241-244 (1982).

Accepted for publication 28th March, 1983.

plants, from different collections of each species, were sputter-coated with gold to about 20 nm thickness with a Polaron E-5000 coating unit, and examined in a Cambridge Stereoscan S-150 Scanning Electron Microscope. No fundamental differences were found in seed-coat patterning in different parts of the seed (Fig. 1).

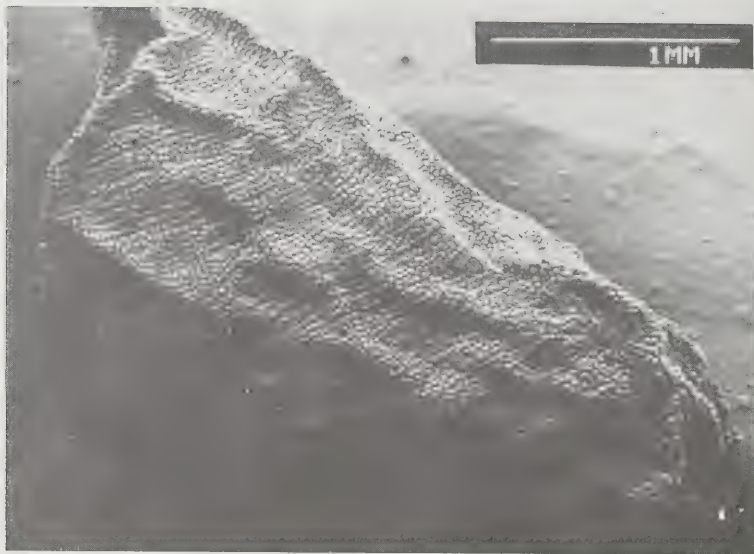


FIG. 1.

T. transvaalensis: the entire seed. Note uniformity of seed-coat pattern, $\times 140$ ca.

RESULTS

The gross morphology of the seed of *Tulbaghia* is very uniform. All species have black on dark-brown coated seeds, which are typically elongated and usually very much creased and compressed into a wedge shape with a somewhat triangular section (Fig. 1).

Scanning Electron Microscopy reveals characteristic cell shapes and sculpturing of the outer cell wall of the testa.

No major differences in testa micro-morphology were observed between seeds from different collections of the same species.

Figures 2, 3, 4 and 5 show the differences between the species.



FIG. 2.

a. *T. capensis*; b. *T. alliacea*; c. *T. cernua*; d. *T. ludwigiana*; e. *T. dregeana*;
f. *T. tenuior*, $\times 500$ ca.

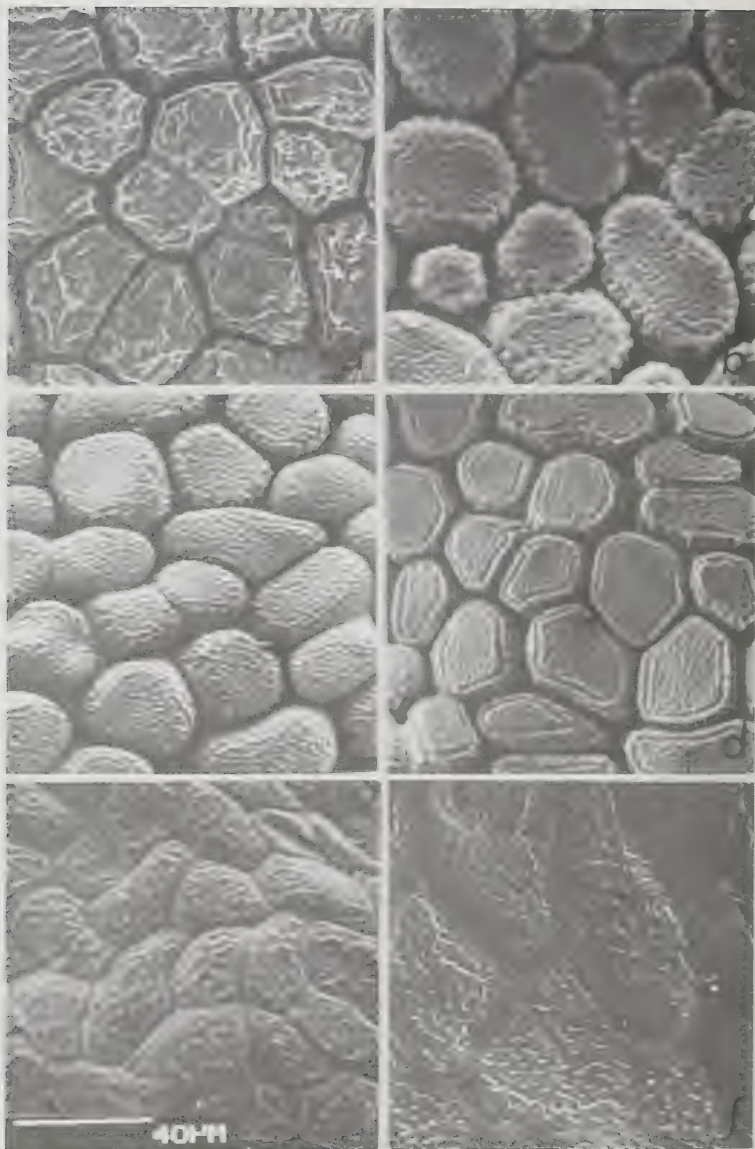


FIG. 3.

a. *T. nutans*; b. *T. macrocarpa*; c. *T. transvaalensis*; d. *T. acutiloba*; e. *T. simmleri*;
f. *T. galpini*, $\times 500$ ca.



FIG. 4.

a. *T. leucantha* ($2n = 2x = 12$); b. *T. leucantha* ($2n = 4x = 24$); c. *T. natalensis*;
 d. *T. verdoornia*; e. *T. coddii*; f. *T. montana*, $\times 500$ ca.

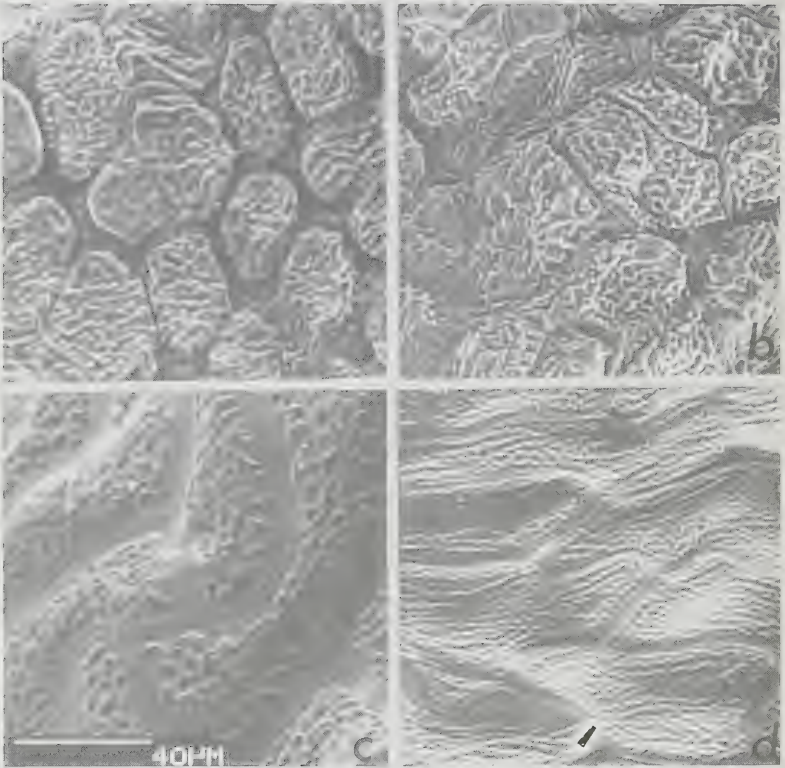


FIG. 5.

a. *T. violacea* from the eastern part of the range; b. *T. violacea* from the western part of the range; c. *T. violacea* var. *maritima*; d. *T. cominsii*, $\times 500$ ca.

DESCRIPTIONS

Figure 2.

a. *T. capensis* L. (C. G. Vosa, 294/14, OXF): clear, distinctly raised cells, depressed and deeply pitted in the centre.

b. *T. alliacea* L.f. (C. G. Vosa, 61, OXF): flat appearance, cells with ribbon-like sutures and covered with an irregular netting of excrescences.

c. *T. cernua* Avé-Lall. (C. G. Vosa, 413/32, OXF and cultivated specimens): a clear papillate surface with somewhat sharp crowded ridges or crests.

d. *T. ludwigiana* Harv. (C. G. Vosa, 398/29, OXF): flattish cells with small excrescences and short ridges.

e. *T. dregeana* Kunth (C. G. Vosa, 62, OXF): somewhat polyhedric, almost smooth cells, with slightly creased upper surfaces.

f. *T. tenuior* Krause & Dinter (C. G. Vosa, 136 OXF): small polygonal cells with a crowded network of shallow ridges.

Figure 3.

a. *T. nutans* Vosa (C. G. Vosa, 536/55, OXF): straight-sided cells with a flat crinkled surface.

b. *T. macrocarpa* Vosa (C. G. Vosa, 132 OXF): round, well separated cells with a flat top covered with shallow ridges.

c. *T. transvaalensis* Vosa (C. G. Vosa, 486/49, OXF): plump, mostly flat-topped cells with minute excrescences and some longish furrows at the edges.

d. *T. acutiloba* Harv. (C. G. Vosa, 347/21, OXF and cultivated specimens): irregular, polygonal, flat-topped cells, with shallow pits ringed with furrow-like sculpturing at the edges.

e. *T. simmleri* Beauv. (C. G. Vosa, 487/50, OXF, and cultivated specimens): irregular shaped cells with well defined sutures and shallow mostly continuous ridges in waving lines.

f. *T. galpini* Schl. (C. G. Vosa, 60, OXF): largish, flat cells with well defined sutures and covered with irregularly shaped pits.

Figure 4.

a. *T. leucantha* Bak. (C. G. Vosa, 430/35, OXF, $2n = 2x = 12$): smooth looking cells with a minute vermiculate appearance.

b. *T. leucantha* Bak. (C. G. Vosa, 449/38, OXF, $2n = 4x = 24$): similar but somewhat larger and rounder cells than the diploid form.

c. *T. natalensis* Bak. (C. G. Vosa, 421/34): very similar to *T. leucantha* but flatter cells with slightly larger vermiculations.

d. *T. verdoornia* Vosa & Burbidge = *T. carnosa* Burbidge (C. G. Vosa, 1599, OXF): flattish, irregular cells with a minutely pitted surface.

e. *T. coddii* Vosa & Burbidge = *T. poetica* Burbidge (C. G. Vosa 496/52): flat appearance with mostly elongated cells covered with a network of more or less regularly spaced pits and raised, ribbon-like sutures.

f. *T. montana* Vosa (Bayliss, 7831, OXF): somewhat polygonal cells with definite boundaries and sharpish, regularly spaced excrescences.

Figure 5.

a. *T. violacea* Harv. (C. G. Vosa, 308/17, OXF): flat-topped cells with a

crinkled and ridged surface and well defined depressed sutures. This collection is from the eastern part of the range.

b. *T. violacea* Harv. (C. G. Vosa, 371/23 OXF): as a. but usually larger more irregular cells. This collection is from the western part of the range of *T. violacea*, about 350 km SW of the a. collection.

c. *T. violacea* Harv. var. *maritima* Vosa (C. G. Vosa, 290/12): large, elongated cells, welded together by ribbon-like smooth sutures, strikingly different from *T. violacea sensu strictu*.

d. *T. cominsii* Vosa (C. G. Vosa, 1568, OXF): irregularly shaped, elongated cells, covered with a network of small excrescences. Cell sutures ribbon-like, well defined and smooth.

Except where indicated, the above descriptions refer to diploid plants. The hexaploid forms of *T. alliacea* and *T. capensis*, as well as the tetraploid form of *T. cernua* (Vosa, 1975), have been investigated and, as in the case of the diploid and tetraploid forms of *T. leucantha*, illustrated in Figure 4, a. and b., no fundamental differences, apart from the average cell size, were found.

DISCUSSION

The differences between *T. alliacea* (Fig. 1, b.) and *T. cernua* (Fig. 1, c.), already discussed by Vosa (1981, pp. 58–61), are also evident in their testa micro-morphology. The flat, well sutured cells of *T. alliacea* are in fact very different from the domed, somewhat bell-shaped cells of *T. cernua*.

The recognized morphological and cytological relationship between *T. leucantha* (Fig. 3, a. and b.), *T. verdoornia* (Fig. 3, d.) and *T. natalensis* (Fig. 3, c.), is confirmed by the similarity of the seed-coat patterns. The further two species in their group (Group 5, Vosa, 1975, pp. 57–60), *T. galpini* (Fig. 2, f.) and *T. coddii* (Fig. 3, e.) possess a testa micro-morphology which is distinct from one another as well as from the other species.

T. alliacea, *T. galpini*, *T. coddii*, *T. violacea* var. *maritima* and *T. cominsii*, though well distinct from each other, share a characteristic testa with a flat-cell appearance and well defined ribbon-like sutures, quite unlike other *Tulbaghia* species.

The existence of such similarity may have an ecological significance in relation to seed dispersal and germination. In this context it is interesting to note that the above five species, with the exception of *T. galpini*, at least in the southern area of its range, normally inhabit humid places which are usually periodically flooded. The possession of close cell sutures may play a part in delaying water uptake, probably permitting longer distance seed dispersal, which, in *Tulbaghia*, is effected by the swaying fruiting stems when the loculicidal capsule opens.

The S.E.M. of the testa micro-morphology of nineteen species of *Tulbaghia* has shown certain unique and species specific features. Apart from the ecological significance, these unique features, as well as the similarities, can be regarded as a useful addition to the more usual characters used in taxonomic identification in *Tulbaghia*.

ACKNOWLEDGEMENTS

I wish to thank Lindsay Helsby, Gavin Wakley and David Kerr for their technical assistance and advice.

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STUDIES IN CYPERACEAE IN SOUTHERN AFRICA: 10. THE GENUS KYLLINGA ROTTB.

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ABSTRACT

A review of the taxonomic history of the genus *Kyllinga* Rottb. is given. Diagnostic criteria are discussed and emphasis laid on the morphology of the underground parts as key characters. Fourteen species are described including two new records for the area, *K. polyphylla* Willd. ex Kunth and *K. nemoralis* (Forst.) Dandy. A key to the genus in South Africa is provided.

UITTREKSEL

STUDIES VAN CYPERACEAE IN SUIDELIKE AFRIKA: 10. DIE GENUS KYLLINGA ROTTB.

'n Oorsig van die taksonomiese geskiedenis van die genus *Kyllinga* Rottb. is gelever. Diagnostiese kenmerke word bespreek en nadruk word op die ondergrondse dele gelê. Viertien spesies word beskryf insluitende twee nuwe rekords vir die gebied, naamlik *K. polyphylla* Willd. ex Kunth en *K. nemoralis* (Forst.) Dandy. 'n Sleutel tot die genus in Suid-Afrika word verskaf.

Key words: *Kyllinga*, Cyperaceae, southern Africa

Generic limits within the Cyperaceae have frequently been subject to differing taxonomic interpretations. *Kyllinga* Rottb. is no exception having been treated as a genus (Vahl, 1806; Nees, 1835/6), united with *Mariscus* Gaertn. (Boeckeler, 1868) and placed in the genus *Cyperus* L. together with *Mariscus*, *Pycneus* Beauv. and *Juncellus* C. B. Clarke (Kükenthal, 1936; Koyama, 1961). This latter treatment has not enjoyed universal acceptance however, and has been challenged on chemical grounds (Allan *et al.*, 1978). In the absence of the unequivocal evidence to support Kükenthal's decision, *Kyllinga* will be maintained at the generic level in this account.

The name *Kyllinga* Rottb. has been conserved in preference to *Thryocéphalum* J. R. and G. Forst. (1776) despite an earlier homonym *Kyllinga* Adans. (Apiaceae) (Lanjouw, 1978). Rottbøll (1773) described *Kyllinga* and five species of which *K. monocephala* was the first mentioned. This species

has been designated the type species (Lanjouw, l.c.) with the correct name *K. nemoralis* (Forst.) Dandy (Dandy, 1935).

Vahl (1806) included Central African species in his list of seven *Kyllinga* species, but the earliest record of South African species was given by Nees (1835/6) with a description of four new species of *Kyllingia*, a spelling now rejected in favour of *Kyllinga*. Kunth (1837) recorded twenty-eight species, commenting that the genus differed from *Pycreus* only in the number of florets, while Boeckeler (1868) gave a rather broader view by including in *Kyllinga* the genus *Mariscus* with its three style branches where *Kyllinga*, in the strictest sense, has two. Bentham and Hooker (1883) and Engler and Prantl (1889) restored *Mariscus* to generic status.

The first comprehensive account of the genus in southern Africa, however, was that of Clarke (1897) which followed his publication of a list of twenty-one African species (1895) and his contribution of six species of African and Indian origin (1893). In his synopsis of the genus, Clarke (1897) recognised three subgenera; *Pseudo-Pycreus*, *Eukyllinga* and *Thryocephalum*, number of nutlets and presence or absence of a wing on the glumes being the diagnostic characteristics. Ten species were recognised but in 1901, Clarke presented a second major account in which thirty-eight tropical species were recognised. This was followed by a species list (1908) and illustrations (1909).

Kyllinga was included in accounts by Schonland (1922) and Brain (1931), but the next major study of the genus was that of Kükenthal (1936) in which the genus *Kyllinga* was reduced to a subgenus of *Cyperus* together with *Mariscus*, *Torulinium*, *Juncellus*, *Pycreus* and *Eucyperus*. The subgenus *Kyllinga* sensu Kükenthal, was further subdivided into sections reflecting Clarke's classification (1897) and within section *Eukyllinga*, three groups were defined on the basis of rhizome characteristics. The arrangement of the three sections suggests an evolutionary progression involving a reduction in number of florets per spikelets and the development of a wing on the keel of the fertile glume.

Koyama (1961) followed Kükenthal adding only the genus *Lipocarpha* R. Br. to the list of those sunk into *Cyperus* sensu Kükenthal. Kern (1974) also included *Kyllinga* within *Cyperus*, but other authors (Podlech, 1960 and Hooper, 1972) do not agree, preferring to retain *Kyllinga* as a separate genus. This latter policy is adopted here.

The genus *Kyllinga* Rottb. is an essentially African genus, but three species are recorded from tropical America and India, four endemic species from the West Indies and seven endemic to the Malagasy Republic. Fourteen species are represented in southern Africa.

Members of the genus may be recognised in the field by their single, compact inflorescence and distinguished from similar forms in *Mariscus* by

their paired style branches. The underground organs, in particular, have a characteristic smell faintly reminiscent of lemon. Each spikelet comprises a pair of sterile glumes (the lower bract and prophyll) subtending distichously arranged fertile glumes. The lowest floret is bisexual, consisting of an ovary with two style branches and three (or 2 or 1) stamens. The upper floret may be male or, rarely, bisexual. Most species produce a single nutlet from the fertile bisexual flower but *K. pulchella* Kunth has 2–4 bisexual flowers and may produce 2 nutlets. There are no hypogynous bristles.

DIAGNOSTIC CRITERIA

Emphasis has been placed on spikelet form, number of nuts, the wing on the keel of the glume and the perennating organs. Each of these was studied and will be discussed together with other characters found to be of interest.

Kyllinga is distinguished from neighbouring genera by its single compact inflorescence of sessile spikelets. In general, this is a consistent feature of the genus though species such as *K. polyphylla* Willd. ex Kunth and *K. elatior* Kunth frequently have minor sessile heads in the axils of lower inflorescence bracts. Two aberrant collections have been made; one a triple head in *K. alba* Nees and one collection of *K. alata* Nees with two peduncled, minor heads reminiscent of *Mariscus*. These are, however, not consistent features for these species.

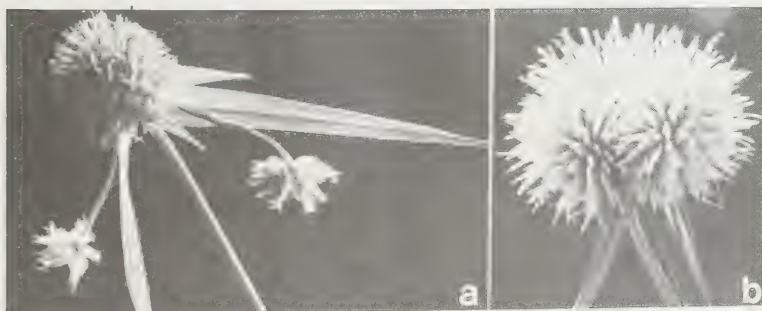


FIG. 1

Anomalous inflorescences of *Kyllinga* species. A. *K. alata* from the Bluff grasslands, Durban. B. *K. alba* from the Lebombo Mountains.

The shape of the inflorescence is useful in separating species. *K. elatior* and *K. odorata* Vahl invariably have cylindrical heads while all the other species have spheroidal heads. Colour is also useful if used with caution. *K. alata* invariably has golden spikelets with green keels giving a characteristic golden inflorescence and *K. pulchella* has deep red inflorescences. *K. odorata*

inflorescences are white when mature, as are those of *K. alba*. In *K. alba* however, some discolouration is possible with cinnamon spots appearing. Associated with the inflorescence are leafy bracts which are useful key characters in some species. The orientation of three stiff bracts, erect at first and later reflexing to a 45° angle, is characteristic of *K. erecta* Schum., *K. intricata* Cherm., *K. brevifolia* Rottb., *K. melanospermia* Nees, and *K. pauciflora* Ridl.. *K. elatior* is easily recognised in the field by its long, horizontally-orientated bracts, but this is not always as apparent in herbarium material and rhizome and inflorescence shape are more reliable here.

Spikelet features have been used as diagnostic features at the subgeneric level and to distinguish species. One of these features was the number of bisexual flowers and thus the number of nutlets per spikelet. In these respect, *K. pulchella* is unique amongst the southern African species in bearing 2–4 (as opposed to one) fertile floret per spikelet.

Kyllinga florets usually include three stamens, but three South African species differ from the norm. *K. brevifolia* invariably has one stamen per floret and *K. odorata* two. *K. welwitschii* Ridley has one or two.

The presence of a wing on the keel of the fertile glumes has been used to define the subgenus *Thryocephalum* (Clarke, 1901) and particular attention has been given to this characteristic. Within a population variation may be very slight, but comparisons of individuals from different populations over the range of distribution of *K. alba* and *K. alata* showed considerable variation (see Figure 2). As a diagnostic criterion some caution must be exercised when using this characteristic. In the present study, wing width was found to be a function of the age of the spikelets of *K. alba* and thus is not a useful diagnostic or key character when dealing with herbarium specimens of this species.

As with many members of the Cyperaceae, the rhizome or other perennating underground stems have proved to be invaluable aids to identification. Indeed, with experience of the genus it is usually possible to make accurate specific identifications of vegetative material on this basis alone.

The term "rhizome" has been used somewhat loosely in the past to describe many types of modified stem found in the genus. In this account, "rhizome" is reserved for those stems which are dorsiventral, creeping, main axes, prostrate on or under the ground, progressively producing aerial shoots in a sympodial pattern. Such rhizomes, however, can be separated into three groups.

- i. Slender elongated rhizomes producing aerial shoots every other node. These are clothed in leaflike scales which may or may not overlap. Examples of this form of rhizome are to be found in *K. elatior*, *K. brevifolia* and *K. intricata* [Fig. 3 (a)].
- ii. Slender or stout compact rhizomes bearing aerial shoots at each

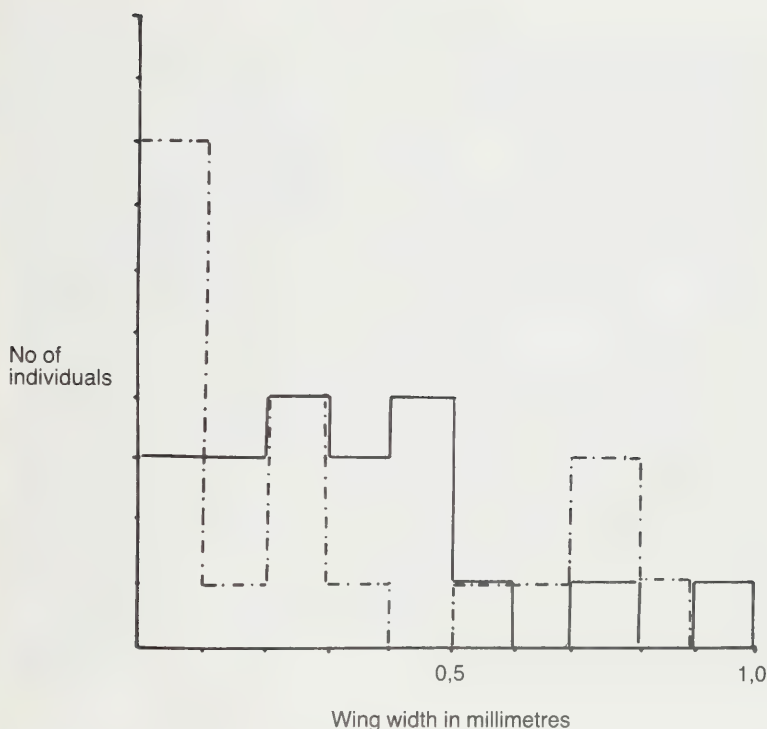


FIG. 2

The range of wing width distribution in twenty individuals of *K. alba* (solid line) and *K. alata* (dotted line).

node. Examples of this type are to be found in *K. erecta*, *K. melanosperma* and *K. polyphylla*. [Fig. 3 (b)].

- iii. Uniseriate rows of woody stem-bases or tufts of woody stem-bases clothed in fibrous sheaths as are found in *K. alba*, *K. alata* and *K. odorata*, all three of which are associated with grasslands. [Fig. 3 (c)].

In contrast to these, three species possess stolons. These lateral branches arise at or below the surface and radiate from the mother plant producing aerial shoots some distance from the mother plant. *K. albiceps* (Ridley) Rendle and *K. pulchella* have extremely slender stolons which are frequently damaged unless collected with great care. Those of *K. nemoralis* are more robust [Fig. 3 (d)].

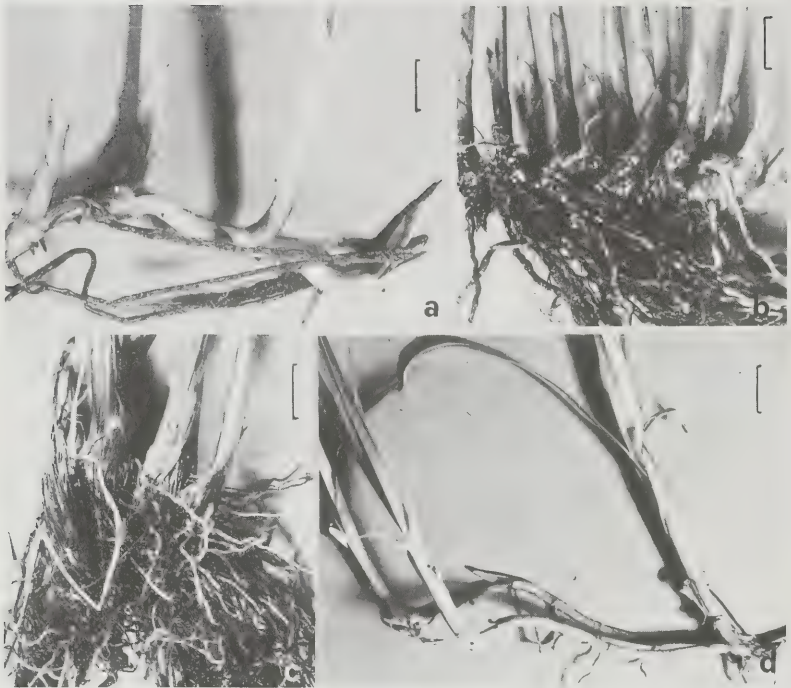


FIG. 3

Underground portions of *Kyllinga* species: a. Elongated rhizomes of *K. elatior*. b. Congested rhizomes of *K. polyphylla*. c. Stem-bases of *K. alba*. d. Stolons of *K. nemoralis*. Scale in each case is equivalent to 10 mm.

The problems of imposing a single-character classification upon a variable genus such as this are evident when considering the subgenera of *Kyllinga*.

Choice of a wing on the keel of the glume to distinguish subgenus *Alata* cannot be upheld in view of the range of variation found. The use of number of nuts to define subgenus *Pseudo-Pycreus* is difficult to justify when some species have one or two nuts. In this account therefore, subgenera are not recognised. If any characteristic were chosen to distinguish groups within this genus, it would be the underground stem, but even here it would lead to artificial groups.

At the species level, however, the nature of the underground stem has been very useful, together with inflorescence form including shape of head, bract and colour.

Kyllinga Rottböll nomen conservanda *Kyllinga* Rottb., Descr. Ic. Nov. P1. 12 (1773) p.p.; Vahl, Enum. P1. II 379 (1806); Nees in Linnaea 9: 286 (1834); Kunth, Enum. P1. II: 127 (1837); Boeck. in Linnaea 35: 403 (1868) (excl. sect. *Pseudo-Kyllingia*); Benth. and Hooker, Gen. P1. 3: 1045 (1883); C. B. Clarke in Hooker, P1. Brit. India 4: 587 (1893), in Thiselton-Dyer, Fl. Cap. 7: 151 (1897) and in Thiselton-Dyer, Fl. Trop. Afr. 8: 266 (1901); Schonland, Intr. to South Afr. Cyper. 19 (1922); Brain in Pro. Rhod. Sc. Assoc. 33: 78 (1934); Hutchinson, in Hutchinson and Dalziel, Fl. West Trop. Afr. 2, 2: 486 (1936); Phillips, Gen. South Afr. Fl. P1. 153 (1951).

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Kyllinga Lestib., Ess. Cyper. 28 (1819); Blanco, P1. Filip. 23 (1845)—

Killyngia Hamilt., Prodr. Pl. Ind. occ. 3 (1825).

Hedychloë Raf. in Ann. Nat. 16 (1820).

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Lyprolepis Steud., Syn. Cyp. 130, (1855).

Cyperus subgenus *Kyllinga* Pax in Engl. and Prantl. Nat. pflanzenfam. 2, 2: 98 (1887); Kükenthal in Engler, Pflanzenr. 4, 20: 556–614 (1936); Tournay in Robyns, Flore des Sperm. du Parc. Nat. Albert. III: 223 (1953).

Type: K. monocephala Rottb. nom. illeg.

(*K. nemoralis* (J. R. & G. Forst.) Dandy ex Hutchinson and Dalziel).

KEY TO SPECIES

1. Inflorescence dense, of many spikelets (always exceeding 20), occasionally accompanied by vegetative shoot (pseudovivipary) 2
 Inflorescence lax, of 15–20 spikelets, or fewer, some replaced by a vegetative shoot. ***K. pauciflora*** Ridley
2. Plants with stolons terminating in aerial stems: in herbarium material these may appear simply as individual plants unless the underground portion is carefully preserved 3
 Plants rhizomatous, series of aerial stems produced on elongated or congested rhizomes sometimes with fibrous sheaths; or tufted 5
3. Inflorescence of 3–1 dark red, sessile, cylindrical spikes ***K. pulchella*** Kunth
 Inflorescence straw-coloured or green, never red; usually spheroidal 4
4. Stolons fleshy, white, radiating in all directions from main plant; spikelets winged, maturing one nutlet ***K. nemoralis*** (J. R. & G. Forst.) Dandy
 Stolons slender, not fleshy, covered with imbricate scales, usually 1 stolon per main plant; spikelet wingless, maturing two nutlets per spikelet ***K. albiceps*** (Ridley) Rend
5. Plants tufted, or with a uniseriate row of woody, swollen stem-bases clothed in fibrous sheaths 6

- Plants rhizomatous; rhizome either congested or elongated; stem-bases not clothed in fibrous sheaths 9
6. Inflorescence cylindrical; stamens 2 or 1 per floret 7
- Inflorescence globose; stamens 3 8
7. Inflorescence pale green to buff when dry; central spike 4–7 mm long; keel of glume ciliate to slightly winged in older spikelets; anthers 1 or 2 per floret; nut narrowly ellipsoid, golden *K. welwitschii* Ridley
- Inflorescence white; central spike 8–16 mm long; keel of glume wingless, glabrous or with 1 or 2 hairs; anthers 2 per floret; nut broadly obovoid, yellow when young turning red-brown later black *K. odorata* Vahl.
8. Inflorescence golden-green, spikelets usually markedly winged ... *K. alata* Nees
- Inflorescence white or cinnamon *K. alba* Nees
9. Rhizome slender, aerial stems distant from one another, produced every other node 10
- Rhizomes compact, aerial stems contiguous, produced at every node 12
10. Stamens 1 per floret; rhizome slender, white with pale brown scales shorter than internodes *K. brevifolia* Rottb.
- Stamens 3 per floret rhizomes not as above 11
11. Inflorescence with 1–3 spikes, central spike elliptic or cylindrical; bracts long (up to 290 mm), horizontally orientated; rhizome 2–3 mm in diam. with transparent membranous scales with striate markings *K. elatior* Kunth
- Inflorescence 1 globose to ovate head; bracts 3 short, lowest erect and later reflexed; rhizome 1–2 mm in diameter with loose, red-brown, overlapping scales *K. intricata* Cherm.
12. Plants generally less than 400 mm; rhizome a row of bulbous-based, contiguous stems clothed in scales (when dry, stem-bases shrunken within the scales), inflorescence a single, globose, golden or green spike . *K. erecta* Schum.
- Plants generally taller, 300–640 mm; rhizome compact, stout (5–8 mm in diameter) not shrinking conspicuously when dried; inflorescence either cylindrical or a group of ovoid or globose heads 13
13. Inflorescence 1, usually cylindric, yellow-green, but subglobose and rust streaked under unfavourable conditions, subtended by 3 stiff erect bracts reflexing to 45° with stem later, with possible 4th very short (120 mm long) bract *K. melanosperma* Nees
- Inflorescence invariably of more than 1, sessile, globose, green spikes subtended by 3–8 spreading bracts, 130–210 mm long *K. polyphylla* Wild. ex Kunth

1. *K. pauciflora* Ridley in Trans. Linn. Soc Ser. 2, 2: 147, t.23, fig 1–4 (1884); C.B. Clarke in Durand and Schinz, Conspect. Fl. Afr. 5:530 (1895), in Thistleton-Dyer, Fl. Cap. 7:152 (1897) and in Flora Trop. Afr. 8:273 (1902), Rendle, Catal. Afr. Pl. Welw. 2:105 (1899); Medley Wood in Trans. S.A. Phil. Soc. 18, 2:250 (1908). Type: Angola, *Welwitsch 6811* (BM, hol.).

Cyperus ridleyi Mattf. and Kükenth. in Engler, Pflanzenr. 20:599 (1936).

Rhizome slender, creeping, elongated, or stems congested and tufted. *Culms* slender, 80–600 mm tall, base scarcely thickened, covered with few sheaths. *Leaves* few, shorter than culm, blades narrow (1–3 mm wide), acuminate. *Bracts* 3, short (30–100 mm) lowest upright, others spreading.

Inflorescence of 1 sub-lateral spike, lax, rarely more than 15 spikelets, golden-green, often exhibiting adventitious plantlets. *Spikelets* long for the genus: 3,4–6,54 mm, ovate-lanceolate in outline, fertile glumes 2, unequal, well developed, plus third upper reduced glume; lower glume 7–9-nerved, subtending bisexual floret, middle 5–7-nerved subtending male (rarely bisexual floret), upper empty; keels green, glabrous or slightly spinulose, excurrent into pointed slightly recurved mucro (0,20 to 0,72 mm). *Stamens* 2, anther connective slightly produced. *Style* long but often exceeded in length by style branches. *Nut* 1, half length of glume, obovoid, golden-brown.

TRANSVAAL—2330 (Tzaneen): Rosendal Dam, Letaba District (-CD), *Scheepers* 1190 (PRE).

—2730 (Vryheid): Wakkeestroom (-AC), *Devenish* 952 (PRE).

NATAL—2829 (Harrismith): Cathedral Peak Forest Reserve (-CC), *Killick* 1103, 1273 (NH, NU).

—2929 (Underberg): Estcourt district, Hlatikulu, Giants Castle area (-BA), *Edwards* 2242 (PRE); Ntabamthlope vlei, Estcourt (-BC), *Downing* 124, 142, 153, 156 (NU), *Getliffe* 298 (NU); Mpendhle, Tillietudlem (-DB), *Huntley* 443 (NU).

—2930 (Pietermaritzburg): Lions River district, roadside near Rawdon's Hotel (-AC), *Gordon-Gray s.n.* (NU), *Getliffe* 224 (NU); Hermansberg district, vlei near school (-BB), *Getliffe* 174 (NU).

K. pauciflora was described as "having the habit of one of the few flowered *Marisci* while the spikelets suggest those of *K. aurata* Nees" Ridley (1884). It was distinguished on the basis of its longer spikelets, few in number, and the presence of "vivipary". (Fig 4b.)

The identity of several Natal gatherings with lax golden inflorescences of very few spikelets (*Huntley* 443, *Killick* 1273 and *Willd* 1439), a gathering from Zimbabwe, has been subject to some debate. Kew determinations placed them in *K. pauciflora* but Robinson (1959) associated them with *K. intricata*. Robinson also suggested that some of his gatherings deserved specific rank as a new species (sp. viii).

Examinations of the Natal specimens and of populations in the field showed that they could not satisfactorily be placed with *K. intricata* as they possessed a more congested rhizome and inflorescences of a maximum of 20 spikelets. The phenomenon called vivipary by Ridley (loc. cit.) was well represented in the Natal populations. Comparison with Robinson's proposed "species viii" suggested these were very similar.

The production of adventitious plantlets is a conspicuous feature of these populations and may be associated with the end of the growing season or with waterlogged conditions. Rhizome structure is interesting and may also exhibit seasonal variation. Elongate internodes of older rhizomes terminate in a cluster of closely packed culms. Herbarium specimens may include both portions if adequately collected or just the terminal congested young por-

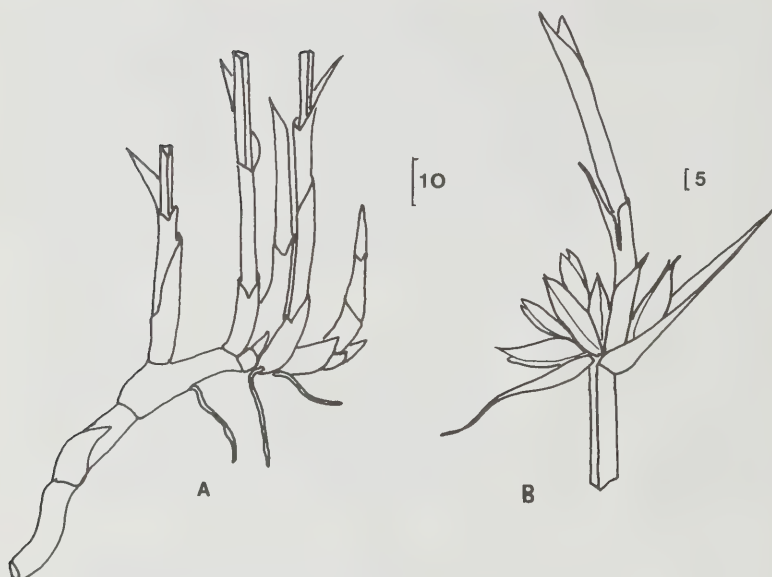


FIG. 4

A. Morphology of the rhizome of *K. pauciflora* with congested stems in young portion and elongated older portions. B. Vegetative shoot replacing one of the few spikelets in the head. Scales in millimetres.

tions. The unique combination of vegetative reproduction and few flowers suggests that all these belong to *K. pauciflora*.

Ridley (1884) commented on the longer spikelets of *K. pauciflora* and a comparison of our material with tropical *K. pauciflora* showed a tendency for our material to have slightly smaller spikelets. There is however no clear distinction between the tropical material averaging 5,09 mm, Robinson's "sp. viii" averaging 4,8 mm and the Natal gatherings averaging 4,13 mm but rather a gradual decrease in size towards the southern limits.

No detailed studies of the breeding strategies of these populations have been carried out to date and the correlation of vegetative propagation with waterlogged marshy conditions has been observed frequently with this and other species, but not tested. Nor can one entirely rule out the possibility that the Natal populations represent hybrid swarms possibly derived from *K. erecta* Schum. Until these questions are resolved, it is proposed that the material be retained in *K. pauciflora* Ridley.

2. *K. pulchella* Kunth, Enum. Pl. 2: 137 (1837); Boeck in Linnaea 35: 405 (1868); C. B. Glarke in Durand and Schinz, Conspect. Fl. Afr. 5: 531 (1895), in Thiselton-Dyer, Fl. Cap. 7: 154 (1897), in Thiselton-Dyer, Flora Trop. Afr. 8: 284 (1901) and in Kew Bull. Addit. Ser. 8: 94 (1908); Burt Davy and Pott-Leendertz in Ann. Tvl. Mus. 132 (1912); Phillips in Ann. S. A. Mus. 16: 319 (1917); Podlech, in Merxm. et al., Prodr. Fl. Südwestafr. 165: 31 (1970). Type: Cape, Albert Division, *Drège* 7384 (K!, holo.).

K. atrosanguinea Steud. in Flora 598 (1842) and Syn. Pl. 2: 69 (1855). Type: Ethiopia, *Schimper* 1269.

Cyperus teneristolon Kükenth., in Engler, Pflanzenr. 4, 20: 574 (1936).

Stolons very slender (less than 1 mm in diam.). *Stem-bases* slightly thickened. *Culms* slender, up to 430 mm tall, triangular, solitary or in small groups, glabrous, glaucous-green, leafy at base. *Leaves* often as long as culms, glabrous, flaccid. *Bracts* 3–4 (see footnote), leaflike, lowest erect, up to 120 mm long, others shorter spreading. *Inflorescence* 1–3 spikes, sublateral when immature, middle spike ovate, up to 16 mm long and 10 mm wide, dark red. Spikelets many, 3–5 mm long, spreading, 3–5 fertile glumes, 2–4 bisexual florets, 3–1 nuts. *Fertile glumes* ovate in outline, lowest 9-nerved, middle 7-nerved, upper 3–5-nerved; keel green or greenish-yellow, wingless, glabrous or with few hairs, excurrent into short mucro. *Stamens* 3, anthers linear, long, connective produced. *Style* long, exerted, stigmas 2. *Nut* ellipsoid to obovoid, half length of glume, chestnut brown.

TRANVAAL—2628 (Johannesburg): Frankenwald (-AA), *Gilliland* 25055 (PRE); Boksburg (-AB), *Munay s.n.* (PRE 29315).

—2729 (Volksrust): 29 km from Volksrust on Amersfoort Road (-BD), *Hilliard* 2991 (NU).

Without precise locality: *Schlechter* 5529 (PRE).

ORANGE FREE STATE—2926 (Bloemfontein): Reddersburg district (-CA), *Acocks* 18696 (PRE).

NATAL—2828 (Bethlehem): Royal Natal National Park (-DB), *Getliffe* 22 (NU).

—2929 (Underberg): Mpendhle, 20 km from Dargle (-DB), *Moll* 680 (NU).

—2930 (Pietermaritzburg): Lions River district, Karkloof (-AC), *Gordon-Gray s.n.* (NU); Mount Gilboa, Karkloof, *Getliffe* 2058 (NU).

LESOTHO—2929 (Underberg): Sehlabathebe Reserve (-CC), *Jacot Guillarmod, Mzamane and Getliffe* 91 (PRE, INCOL).

CAPE—3025 (Colesberg): 16 km SW Colesberg (-CA), *Acocks* 16310 (PRE).

—2337 (Stutterheim) Mount Cume, Dohne (-CB), *Acocks* 9495 (PRE); *Hilner* 359 (PRE); Komgha (-DB), *Flanagan* 1261 (K, NH, PRE).

Also found in Ethiopia, Kenya and Tanzania.

Acocks 18696 consisted of two plants one of which has about 14 bracts. Each of the four heads comprising the inflorescence appears to have a full complement of bracts. This is, however, an exception to the general rule that bract number in the species is 3 or 4.

Kyllinga pulchella is distinguished from all other southern African species by its dark red inflorescences. It has not been widely collected though Clarke (1901) remarked that it was "frequent in South Africa". Careful collection is necessary to include the characteristic delicate stolons. A tropical species of *K. anomala* Peter & Kükenth. may be its nearest relative, but is distinguished from *K. pulchella* by its peduncled axillary spikes and red keels to the glumes whereas those in *K. pulchella* are green. These distinctions may not be sound and Napper (1971) has amalgamated both into *K. pulchella*. *K. pulchella* is a distinct species in South Africa differing from the only other species with slender stolons, *K. albiceps*, in the striking red colour of its spikes.

3. ***K. nemoralis*** (J.R. and G. Forster) Dandy, ex Hutchinson and Dalziel, Flora W. Trop. Afr. 2, 2: 487 (1936), Nelves and Baldwin in Amer. Journ. Bot. 39: 389 (1952), Hooper in Hepper, Flora W. Trop. Afr. ed. 2, 3: 307 (1972)

Thryocephalon nemorale J. R. and G. Forster, Charact. Gen. Pl. 129, t 65 (1776).

Kyllinga monocephala Rottb., Desc and Icon Nov. Pl. 13, fig 4 (1773); Nees, in Wight, Contrib. Bot. of India 91 (1834); Kunth, Enum. Pl. 2: 129 (1837); Steud., Synops. Cyp. 2: 67 (1855); Boeck. Linnaea 35: 427 (1868) p.p, Ridl. in Trans. Linn. Soc. 2. Ser Bot 2: 147 (1884); C. B. Clarke, in Hooker, Fl. Brit. Ind. 6: 588 (1893), in Durand and Schinz, Conspect. Fl. Afr. 8: 530 (1895), in Thiselton-Dyer, Fl. Trop. Afr. 7: 272 (1902) and Illustr. Cyp. t ii. f 1-2 (1909); Chermeson, Catal. Pl. Madag. 8 (1931). Type: Rottb., Desc. et Icon. Nov. Pl. 13, fig. 4. (Iconotype).

Cyperus kyllinga (Endl.) Kükenth., in Engler Pflanze. 4, 20:606 (1936).

Plants with stolons, 10-100 mm long, slender, white and pliable when fresh, fragrant, about 2 mm in diam., with membranous, pink-brown, striate scales, developing fine feathery roots. *Culms* usually distant, occasionally clustered, 40-570 mm tall, flaccid (except Getliffe 193), triangular, bases not thickened. *Leaves* usually shorter than culms, sheaths membranous, lowest pinkish-brown, striate; blades 3-5 mm wide, flat, margins and keels hybrid particularly near apex, flaccid (except Getliffe 193). *Bracts* 3-4, 1 100-1 300 mm long, clasping inflorescences, upright later reflexed or spreading. *Spikelets* many, ovate elliptic in outline, 2.95-5 mm long, floret 1 bisexual rarely second male floret, fertile glumes 2 sometimes with third reduced hyaline glume, sides of both well-developed glumes obscurely nerved, 3-4 prominent nerves close to thick fleshy green winged keel that is excurrent into slightly recurved mucro 0.5-0.8 mm long; wing 0.1-0.15 mm wide, spinulose. *Stamens* 3. *Style* long, slender, bifid. *Nut* 1, less than $\frac{1}{2}$ length of

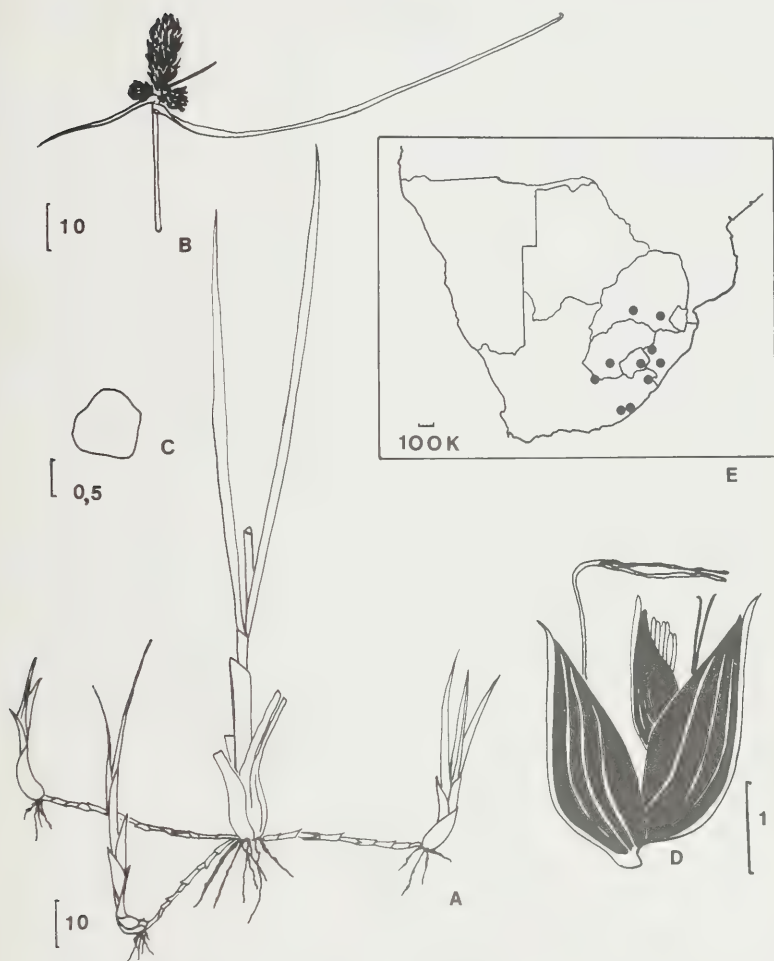


FIG. 5

Morphology and distribution of *K. pulchella* in southern Africa. A. Basal portion of a shoot with slender stolons terminating in erect shoots. B. Multiple heads often found in this species. C. Cross-sectional outline of the culm. D. Dark red spikelet (lower empty glumes, a bract and prophyll, removed) with three fertile glumes maturing at least two nutlets. E. Distribution of *K. pulchella* in southern Africa. Figure scales in millimetres; map scale in kilometres.

spikelet, obovoid to oblong, butter yellow turning red-brown, later black, slightly apiculate.

NATAL—2832 (Mtubatuba): 16 km N of Mtubatuba (-AC), *Getliffe 59, 123* (NU); Dukuduku (-AD), *Ward s.n.* (NU).
—2930 (Pietermaritzburg): Isipingo Beach (-DD), *Ward 1250* (NU).
—2931 (Stanger): Durban Country Club Golf Course (-CC), *Getliffe 193* (NU); Durban Botanic Garden, *Getliffe 996* (J).

K. nemoralis has been described as "very general in warmer parts of the Old World particularly near the sea" (Clarke, 1897) and as a weed of secondary forest and disturbed areas (Hooper, 1972). Clarke (1897) cited only two doubtful records from Africa but it has subsequently been included in accounts of African material (Kükenthal, 1936; Napper, 1971; Hooper, 1972b) with the most southern record in Mozambique. During this investigation five records of this species have been studied. All were coastal, two in areas which have been subject to considerable disturbance (a golf course and a densely populated resort) and a third on the fringe of a pond in the Botanic Garden where it is frequently mowed.

These Natal gatherings agree with descriptions of *K. nemoralis* though the term stolon is preferred here to "slender rhizome" (Napper, 1971). One distinctive feature not previously recorded for this species, is the presence of "vivipary" in these populations. Small adventitious propagules arise in the inflorescence, apparently replacing a spikelet. In *Cyperus prolifer* Lam., this phenomenon was observed to be correlated with disturbance and waterlogging (Getliffe & Baijnath, 1976). In *Kyllinga nemoralis* it may reflect a reaction to similar conditions. Once again, the underground portions are the key diagnostic character and this is not always included in herbarium specimens. Without reference to these slender stolons the species may be confused with *K. brevifolia* or *K. elatior*, but it differs from both in the presence of a winged keel to the glumes. Its fleshy stolons distinguish it from the other stoloniferous species, *K. pulchella* and *K. albiceps*, in which the stolons are very slender.

4. *K. albiceps* (Ridley) Rendle in Cat. Afr. Pl. Welw. 2: 106 (1896), C. B. Clarke in Thiselton-Dyer, Flora Trop. Afr. 8: 286 (1901); Hutchinson in Flora W. Trop. Afr. 2, 2: 486 (1936).

K. macrocephala A. Rich var. *angustior* C. B. Clarke, Conspect. Fl. Afr. 5: 529 (1895). Type: *Scott Elliott 7626* (K, holo.!).

K. merxmuelleri Podlech, Mitt. Staatssamml. Münch. 3: 525 (1960), in Prod. Fl. Südwestafr. Fam. 165. L. 16:31 (1967). Type: Vley 16 ml Östlich Runtu. *Merxmueller and Giess 2136* (PRE, iso.!).

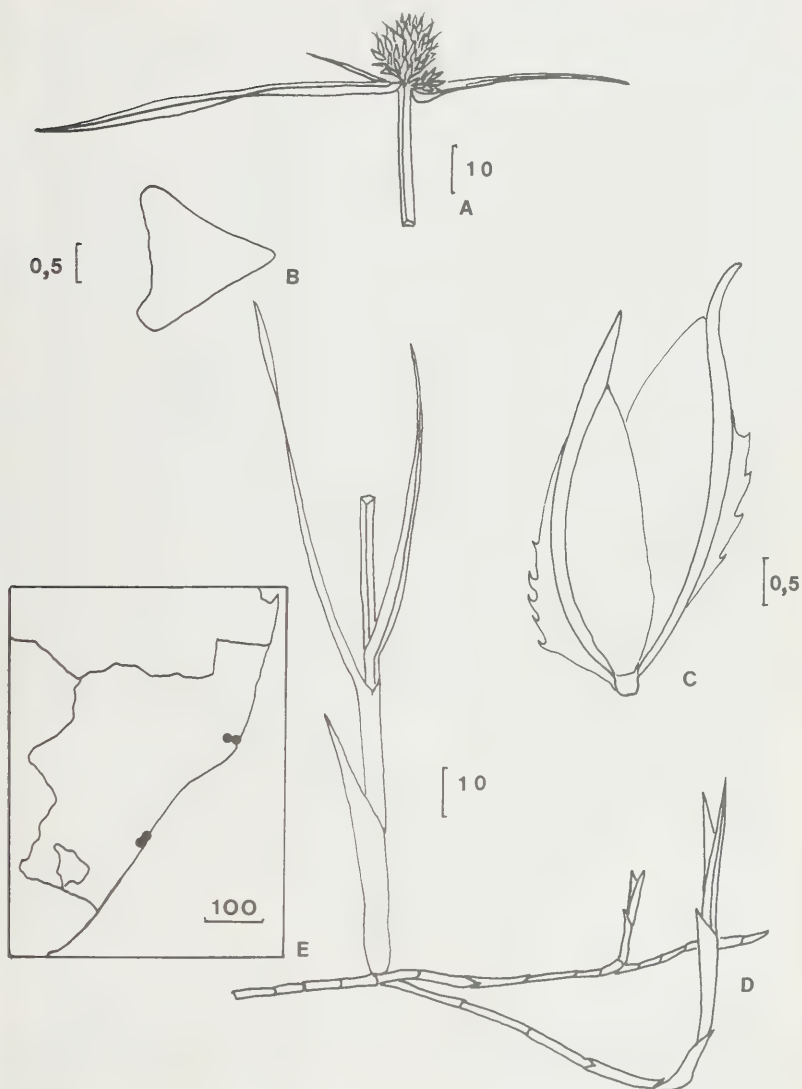


FIG. 6

Morphology and distribution of *K. nemoralis*. A. Inflorescence with lateral subsidiary spike. B. Cross-sectional outline of culm. C. Single winged spikelet (lower empty bract and prophyll removed). D. Portion of shoot with prominent stolons radiating from parent plant. E. Distribution along Natal coast. Figure scales in millimetres; map scale in kilometres.

Cyperus albiceps Ridley, Journ. Bot. 22: 16 (1884). Type: Congo, Christian Smith (BM, holo.).

Cyperus richardii Steud. var. *angustior* (C.B. Clarke) Kükenth. in Engler, Pflanzenr. 4, 20: 570 (1936).

Stem-bases woody, swollen, sheathed, stoloniferous. *Stolons* 1 mm wide, up to 500 mm long, covered with bracts which later split into fibres. *Culms* solitary, up to 300 mm long, slender, compressed triangular, glabrous, leafy at base. *Leaves* shorter than culms, 2–5 mm wide, flaccid, acuminate. *Bracts* 2–3, erect, later reflexed, leaflike, longest up to 95 mm long. *Inflorescence* of 1 globose or ovoid spike or 2–3 spikes confluent into subglobose head, up to 8 mm in diam, straw-coloured. *Spikelets* many, ovate-elliptical in outline, less than 3 mm long, 2-flowered, 2–3 fertile glumes. *Fertile glumes* straw-coloured, sometimes gland-dotted, 7–9-nerved, keel probably green when fresh, fading to straw, excurrent into short mucro. *Stamens* 3. *Style* almost equal in length to style branches. *Nuts* 2, ellipsoid to oblong, half length of glume, golden-brown.

S.W.A.—1719 (Runtu): Vley 16 ml Östlich Runtu (-DD), Merxmüller and Giess 2136 (PRE).

—1814/1816: Ovamboland, de Winter and Giess 6900 (PRE).

K. macrocephala var. *angustior* was differentiated from *K. macrocephala* by its smaller inflorescence and shorter spikelets but transferred by Clarke (1901) to *K. albiceps* (Ridley) Rendle with the remark that it differed very little from *K. macrocephala*, but for the slender stems. There are undoubtedly two entities here; a tropical group and one which also has a southern element. Both were examined and the difference in spikelet length and inflorescence length was confirmed. A more significant difference however is the difference in the number of bisexual florets. In *K. macrocephala*, more than two nutlets were produced while the group assigned to the variety of *K. albiceps*, have only two fertile florets. The type of Clarke's variety, *K. macrocephala* var. *angustior* (Scott Elliott 7626) bears the comment in Clarke's hand that it has three nuts. However, examination of this specimen could not confirm this and the material examined suggests that two nutlets are characteristic of the variety. The isotype of *K. merxmülleri* and a second gathering cited by Podlech (1960) were examined and found to agree in every respect with *K. albiceps* which epithet has precedence.

This species shares the delicately stoloniferous habit of *K. pulchella* but its buff inflorescences are readily distinguished from the dark red inflorescences of *K. pulchella*.

5. *K. welwitschii* Ridley, Trans. Linn. Soc. Ser. 2, 2: 147 (1884); Hooper in Hepper, Flora W. Trop. Afr. ed 2, 3: 305 (1972). Type: Angola, Pungo Andongo, Welwitsch 6796 (K, holo.; BM, iso.).

K. blepharinota Hochst. ex Boeck., in *Linnaea* 35: 414 (1868).

K. caespitosa Ridl. (non Nees) in *Trans. Linn. Soc. Ser. 2*, 2: 145 (1884).

K. triceps var. *ciliata* Boeck. in *Linnaea* 35: 414 (1868); C. B. Clarke in Durand and Schinz, *Conspect. Fl. Afr.* 5: 533 (1895) and in Thiselton-Dyer, *Flora Trop. Afr.* 8: 281 (1901); Kükenthal in Engler, *Pflanzenr.* 4, 20: 579 (1936). Type: Abyssinia, *Schimper 2201*.

K. controversa var. *subexalata* C. B. Clarke in Thiselton-Dyer, *Flora Trop. Afr.* 9: 271 (1901).

Cyperus controversus var. *subexalatus* (C. B. Clarke) Kükenth., in Engler, *Pflanzenr.* 4, 20: 612 (1936).

Plants tufted or with short row of thickened, woody, stem-bases clothed in persistent, tough sheaths. Culms 40–50 mm tall, very slender, triangular, furrowed, glabrous. Leaves shorter than culms, blades 1–2 mm wide, glabrous or margins and keel minutely scabrid, flaccid, markedly acuminate. Inflorescence of 3–1 spikes, pale green to buff-coloured when dry, dense; central oval, 4–7 mm long, lateral smaller, subglobose. Bracts 3, up to 8 mm long, sometimes with 1 additional, very reduced bract. Spikelets numerous, elliptic in outline, 1.5–2.5 mm long; fertile glumes 3; lowest subtending bisexual floret, white scarious gland-dotted, obscurely 5-nerved, keel probably green, scarcely excurrent into mucro, ciliate, slightly winged in older spikelets; middle glume fully developed, empty, otherwise as in lowest glume but 3-nerved; uppermost glume minute, hyaline. Stamens 2–1. Style and style branches shorter than mature nut, style branches exceed style in length. Nut 1, narrowly ellipsoid, approximately 1.5×0.5 mm, golden.

S.W.A.—2115 (Karibib): Okongava, Granitbank (-BB?), *Dinter 6961* (PRE); Farm Neuschwaben (-DD), *Kinge 3048* (PRE).

Also found in West Africa, Tanzania and Mozambique.

The taxonomic delimitation of *K. welwitschii* Ridley has had a varied history. Clarke (1895) cited, under *K. triceps* var. *ciliata*, nineteen African specimens including eight Welwitsch gatherings which, according to Robinson (1959), are plants with immature spikelets. One of these is the type of *K. welwitschii* Ridley. In 1901, Clarke reorganised *K. triceps* var. *ciliata* leaving the Welwitsch gatherings in that variety but transferring the remaining specimens to *K. controversa* var. *subexalata* C. B. Clarke. The only difference between these two groups of specimens was the presence, in the latter, of a very narrow wing on the keel of the glume. No measurements were given but the varietal epithet suggests it was a very narrow wing. The Welwitsch gatherings remaining in *K. triceps* var. *ciliata* were immature and this is significant for in the present study it was found that wing width was a factor of the age of the spikelets.

Thus, the two varieties cannot be upheld but must be regarded as one taxon. Present studies show that the difference between this taxon and *K. triceps* are real and of sufficient significance to warrant specific recognition, however it cannot be assigned to *K. controversa* as they are quite distinct from this rather doubtful species. *K. welwitschii* Ridley is the oldest valid name and is consequently applied to this taxon. This species is distinguished from other tufted species by its pale green multiple heads of sessile spikes, and the presence of 2 (or 1) stamens.

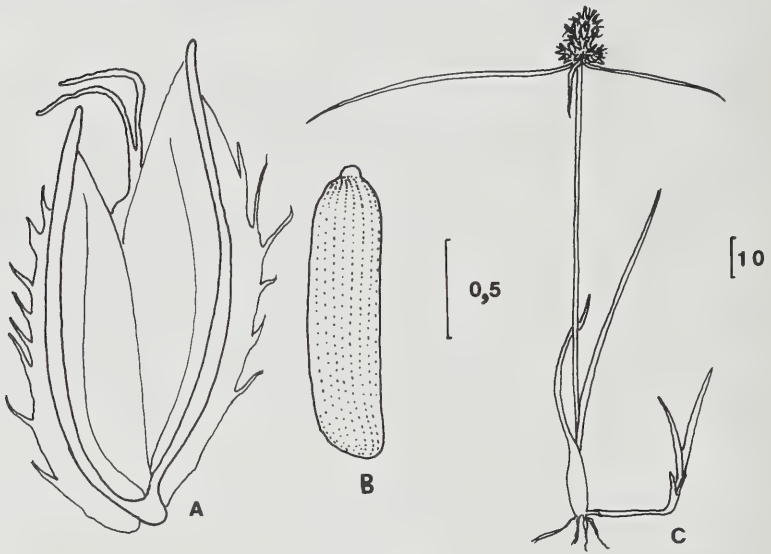


FIG. 7

A. Spikelet of *K. welwitschii* with two fertile winged glumes (lower prophyll and bract removed). B. Slender elongated nutlet removed from spikelet. C. Plant with slender stolon terminating in a new shoot. All scales in millimetres.

6. *K. odorata* Vahl, Enum. Pl 2: 382 (1806); Nees, Linnaea 9: 286 (1834); Kunth, Enum. Pl. 2: 132 (1837); Boeck., Linnaea 35: 410 (1868); C. B. Clarke, Kew Bull. Add. Ser. 8: 93 (1908); Hutchinson in Hutchinson and Dalziel, Flora W. Trop. Afr. 11, 2: 487 (1936); Hooper in Hepper, Flora W. Trop. Afr. 2: 304 (1972). Type: Habitat in Americo meridional v. Rohr. Richard (not traced)

Cyperus sesquiflorus (Torr.) Mattf. and Kükenth. in Engler, Pflanzenr. 4, 20: 591 (1936).

C. sesquiflorus var. *cylindricus* (Nees) Kükenth. in Engler, Pflanzenr. 4, 20: 592 (1936).

K. cylindrica Nees in Wight, Contrib. Bot. India: 91 (1834) and Linnaea 9: 286 (1934); Kunth, Enum. Pl. 2: 133 (1837); Boeck., Linnaea 35: 415 (1868); C. B. Clarke in Hooker f., Fl. Brit. India 6: 588 (1893); in Durand and Schinz, Conspect. Fl. Afr. 5: 528 (1895), in Thiselton-Dyer, Flora Cap. 7: 153 (1897), in Thiselton-Dyer, Flora Trop. Afr. 8: 282 (1901) and in Kew Bull. Add. Ser. 8: 93 (1908); Medley Wood, in Trans. S.A. Phil. Soc. 17, 2: 250 (1908). Type: India, herb. Royle no. 39 (LIV, holo).

K. triceps Rottb. var. *obtusiflora* Boeck., Linnaea 414 (1868).

Cyperus triceps var. *obtusiflorus* (Boeck.) Kükenth., in Engler, Pflanzenr. 4, 20: 579 (1936).

Roots fibrous. *Plants* tufted or forming short row of old sheathed stem-bases. *Culms* up to 540 mm tall, triangular, ridged and furrowed, glabrous, scarcely thickened at base. *Leaves* many, tufted at base of culm, half length of culms; sheaths short, brown; blade 2–4 mm wide, margins and keels scabrid. *Inflorescence* of 1–3 dense, white spikes; central cylindric, 8–16 mm long, 5–7 mm wide; lateral small, globose to cylindric. *Bracts* 3–4, leaflike, longest up to 93 mm long. *Spikelets* many, 2.47–2.52 mm long, broadly ovate in outline, tapering to acute apex, 1- (rarely 2)-flowered, fertile glumes 2, almost equal, lower 9-nerved, upper 5–7-nerved, sometimes enclosing third reduced hyaline glume; keel wingless, smooth or with 1–2 hairs, green, keel of lower glume slightly excurrent into mucro. *Anthers* 2. *Style* short, exceeded in length by style branches. *Nut* broadly obovoid, apex truncate, $\frac{2}{3}$ length of spikelet, yellow to red-brown, later black.

TRANSVAAL—2330 (Tzaneen): Westfalia Estate (-CA), Scheepers 17 (PRE). —2430 (Pilgrims Rest): Mariepskop district (-DB), van der Schijff 4946 (PRE).

NATAL—2830 (Dundee): 3 miles N of Kranskop (-DC), Getliffe 212 (NU).

—2831 (Nkandhla): Shongweni (-AA), Ross 773 (NU); Ngoya Reserve (-DC), Getliffe 216 (NU); Mtunzini "Hamewith" (-DD), Mogg 4428, 4522 (PRE).

—2930 (Pietermaritzburg): Burdons Farm, Karkloof (-AC), Wells 1089 (NU); "The Dargle", Getliffe 179 (NU); 3 miles up Curry's Post Road from Balgowan, Downing s.n. (NU); "The Start", Getliffe 203 (UN); "Rosebank", Durban Road, Greytown (-BA), Getliffe 195 (NU); Ahren, Mowbray, Fisher 953 (NU, PRE); Hermannsburg, vlei near school (-BB), Getliffe 172 (NU); Noodsberg Road, past Montebello turnoff (-BD), Getliffe 1658 (NU); Kings Cliff, Noodsberg Road, Getliffe 166 (NU); Town Bush Valley (-CB), Ward 117b (NU), Ross 721 (NU); Chase Valley, Getliffe 24 (NU), Ross 729 (NU); Portals Farm, Raisethorpe, Ram s.n. (NU); Pietermaritzburg Country Club, Ross 726 (NU); Thomas Moore School, Fields Hill, Getliffe 175 (NU); Pinetown Govt. Indian School, Getliffe 229 (NU).

—2931 (Stanger): Howard College (-CC), Getliffe 177 (NU).

CAPE—3129 (Port St. Johns): Port St. Johns above Tiger Flats (-DA), Galpin 2846 (PRE).

K. odorata is based on American material and *K. cylindrica* on Indian specimens. African gatherings have been assigned to both of these, but Kükenthal (1936) regarded them as two variations of *C. sesquiflorus*.

K. odorata was relegated to *C. sesquiflorus* var. *sesquiflorus* distinguished by its wider inflorescence and longer spikelets from the variety *cylindricus* (= *K. cylindrica* Nees).

Particular attention was therefore paid to these two characters in a survey of African material, including Welwitsch gatherings cited by Kükenthal. All specimens seen had inflorescences well within the range of the type and the spikelet length ranged from 2,3 to 3,25 mm without any discontinuity into two groups. Doubts about the separation of the taxon into two varieties were confirmed when specimens seen by Kükenthal did not fit his delimitations. It is apparent that no purpose is served in splitting this variable material into two varieties; accordingly only *K. odorata* Vahl is upheld. This species is characteristic of grassland habitats and its distinctive cylindrical head, frequently subtended by two smaller globose heads makes it readily distinguishable from other grassland forms. The nuts ripen to glossy black and are visible through the glumes giving mature heads a mottled appearance.

7. *K. alata* Nees, Linnaea 9: 281 (1834), Linnaea 10: 139 (1835–36); Kunth, Enum. Pl. 2: 136 (1837); Steud., Synops. Cyp. 69 (1855); Boeck, Linnaea 35: 430 (1868). Type: locis humidis arenosis ad “Koegakammaklog” et flumen Zwartkopsrivier alt II, Ecklon 883. (S, iso.?!).

Kyllinga alba var. *alata* (Nees) C. B. Clarke in Durand and Schinz, Consp. Fl. Afr. 5: 526 (1895), in Thiselton-Dyer, Flora Trop. Afr. 8:272 (1901); Burt Davy and Pott-Leendertz, Ann. Trans. Mus. 132 (1912); Phillips, Ann. S.A. Mus. 16: 318 (1917); Schonland, Mem. bot. Surv. S. Afr. 3: 19, t. 1 (1922).

Cyperus alatus (Nees) F. Muell., Fragm. 8: 272 (1874); Kükenth. in Engler. Pflanzenr. 4, 20: 611 (1936).

Plants tufted, forming a short row of sheathed stem-bases, sheaths brown, tough, fibrous. *Culms* frequently, but not invariably, ciliate-pubescent below inflorescence. *Leaves* numerous, flaccid, generally more than half length of culm; *sheaths* less than $\frac{1}{3}$ length of culm, blade up to 5 mm wide, margin and keel scabrid, especially in young leaves. *Inflorescence* a single ovate to globose spike, rarely 2 additional lateral peduncled spikes [Getliffe 305 (NU).], golden-green. *Bracts* 3–4, occasionally reduced to 2. *Spikelets* many, approximately 6 mm long, ovate-lanceolate in outline, fertile glumes 2, almost equal, subtending 2 bisexual florets or upper male, both keels green, excurrent into long slender mucros, lower 0,5–1,2 mm (av. 0,87 mm) upper 0,27–1,04 mm (av. 0,67 mm). Wing narrow in young

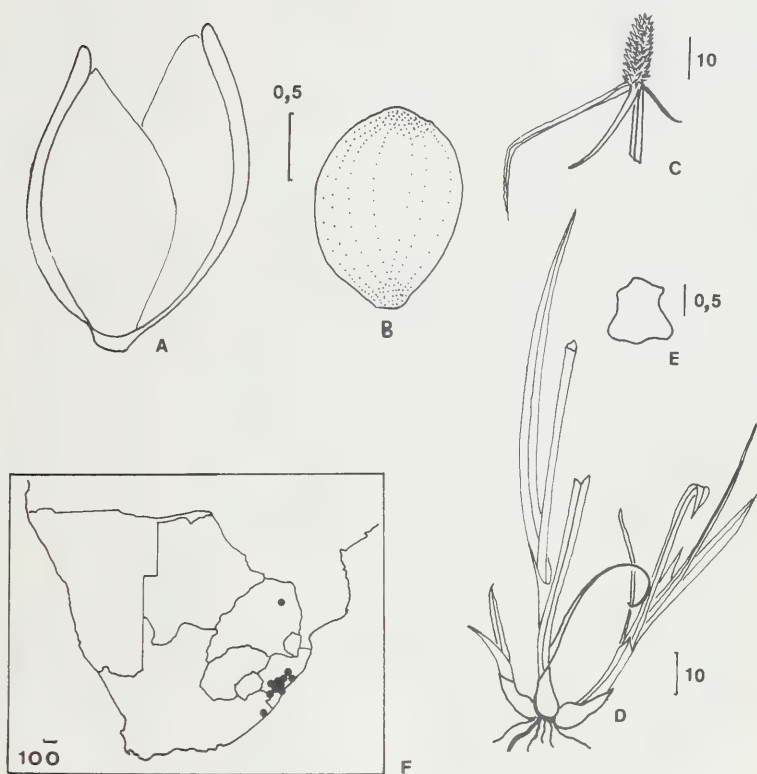


FIG. 8

Morphology and distribution of *K. odorata*. A. Spikelet with lower empty glumes removed. B. Large young golden fruitlet before maturing to black. C. Cylindrical inflorescence. D. Basal portion of leafy shoots with swollen stem-bases in cluster. E. Cross-sectional outline of culm. F. Distribution in southern Africa. Figure scales in millimetres; map scales in kilometres.

specimens, up to 0.85 mm wide in older, ciliate, golden-green. *Stamens* 3. *Style* shorter than style branches. *Nut* 1 or 2, obovoid, yellow, turning red-brown when mature.

S.W.A.—2116 (Okahandja): Grootfontein District, Okahandja (-DD), *Bradfield* 137 (PRE).

TRANSVAAL—2529 (Witbank): Middelburg (-CD), *Gower s.n.* sub PRE 29308 (PRE); *van der Merwe M.B.* 07 (PRE).

—2530 (Lydenburg): Belfast (-CA), *Leendertz* 9211, 9566 (PRE).

- 2626 (Klerksdorp): Hakboslaagte (-AC), *Kinges 1521* (PRE).
- 2628 (Johannesburg): Frankenwald (-AA), *van Rensburg s.n.* (-AD), *Leendertz 8011* (PRE).
- 2629 (Bethal): Ermelo (-DB), *Collins 12223* (PRE).
- ORANGE FREE STATE—2926 (Bloemfontein): near racecourse, Bloemfontein (-AA), *Potts 3002* (NU).
- NATAL—2632 (Bela Vista): 3,2 km from Kosi Nature Reserve (-DD), *Edward 2570* (PRE).
- 2732 (Umbombo): Mbaswana (-BC), *Michelmores 28* (PRE).
- 2832 (Mtubatuba): Hlabisa district, Charters Creek (-AB), *Ward 2776* (NH, PRE).
- 2929 (Underberg): Mooi River, Meteor Ridge (-BB), *Mogg 7066* (PRE).
- 2930 (Pietermaritzburg): The Dargle (-AC), *Getliffe 190* (NU); Fawn Leas (-BC), *Getliffe 169* (NU).
- 2931 (Stanger): Durban flats (-CC), *Medley Wood 4014* (NH); Wentworth, Bluff, *Getliffe 305* (NU), *Getliffe 1008* (J).
- 3029 (Kokstad): Harding District, Bedford Farm (-DB), *Lennox s.n.* (NU).
- CAPE—3029 (Kokstad): Bizana (-DD), *Strey 4336* (PRE).
- 3125 (Steynsburg): Steynsburg (-BD), *Acococks 13527* (PRE); Maraisburg district near Hofmeyer (-DB), *Acococks 16333* (PRE).
- 3227 (Stutterheim): Toise River (-DA), *Hilner 529* (PRE).
- 3228 (Butterworth): Kei Mouth (-CB), *Flanagan 927* (PRE).
- 3326 (Grahamstown): Port Alfred (-DB), *Potts 226* (BLFU).
- 3421 (Riversdale): Riversdale (-AB), *Muir 3586* (PRE).
- 3423 (Knysna): Knysna (-AA), *Breyer 23639* (PRE).

K. alata, described as a new species by Nees (1834), was relegated to a variety of *K. alba* by Clarke (1897 and 1901). Clarke used colour of glumes, width of wing on the glume and pubescence of culms to distinguish these taxa but did not mention the difference in mucro length and shape to which Nees (1935–36) drew attention.

Colour is reliable in the field where the golden spikelets of *K. alata* are conspicuously different from the white heads of *K. alba*, but in herbarium material is not always well preserved. Wing width varies with age, but is a reliable character in mature specimens, and pubescence of culms, particularly immediately below the inflorescence, is useful. Though some variation can be expected in *K. alata* in this character, no specimen *K. alba* was seen to be pubescent. While colour, wing width and pubescence may not be diagnostic when used separately, these characters used in combination separate *K. alata* from *K. alba*. Mucro length is, however, a very useful diagnostic character. Using a sample of twenty specimens from each taxon from the entire range of distribution, it was established that the presence of two long, curved mucros per spikelet of *K. alata* was a consistent characteristic and contrasted with the single (lower), straight mucro of *K. alba*.

K. alata is restricted to a southern African distribution while *K. alba* is also found in tropical Africa.

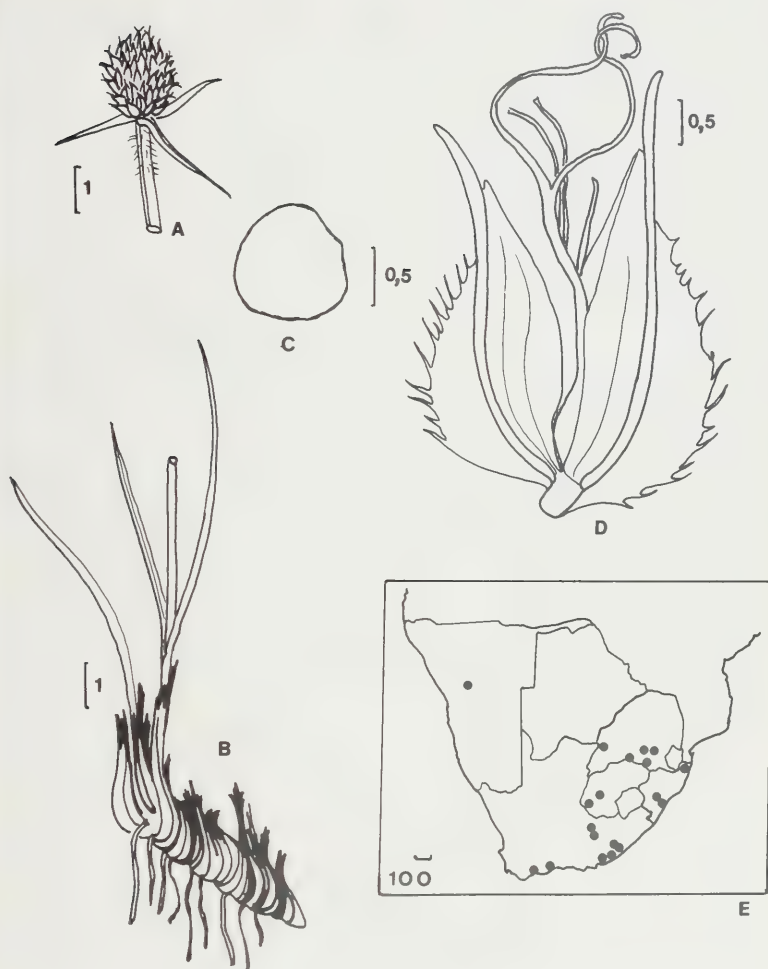


FIG. 9

Morphology and distribution of *K. alata*. A. Terminal spike subtended by short bracts, on a ciliate culm. B. Stem-bases clothed in fibrous sheaths. C. Cross-sectional outline of culm. D. Fertile winged glumes enclosing single nutlet. E. Distribution of the species in southern Africa. Figure scales in millimetres; map scale in kilometres.

8. *K. alba* Nees, *Linnaea* **10**: 140 (1836–36); Kunth, *Enum. Pl.* **2**: 136 (1837), *Ridl. Trans. Linn. Soc. Ser. 2*, **2**: 147 (1884); Clarke in Durand and Schinz, *Conspect. Fl. Afr.* **5**: 526 (1895), in Thiselton-Dyer, *Flora Cap.* **7**: 151 (1897), in Thiselton-Dyer, *Flora Trop. Afr.* **8**: 271 (1901), and *Kew Bull. Addit. Ser.* **8**: 93 (1908), Burt Davy and Pott-Leendertz, *Ann. Tvl. Mus.* **132** (1912); Phillips, *Ann. of S.A. Mus.* **16**: 318 (1917); Dyer, *Rec. of Alb. Mus.* **3**: 476 (1927); Schonland, *S. Afr. Cyp.* **19** (1922); Brain, *Proc. Rhod. Sc. Assoc.* **33**: 78 (1934). Type: South Africa "in utroque latere fluminis 'der zwarte Keyrivier' dicti alt III" Ecklon (S?, holo.).

Kyllinga cristata Kunth, *Enum. Pl.*: 136 (1837).

Kyllinga nigritana C. B. Clarke, in Thiselton-Dyer, *Fl. Trop. Afr.* **8**: 272 (1902).

K. alba Nees var. *nigritana* (C.B. Cl.) Podlech, *Mitt. Staatssamml. Münch.* **3**: (1960).

Cyperus cristatus (Kunth) Mattf. & Kükenth. in Engler, *Pflanzenr.* **4**, 20: 609 (1936).

Cyperus cristatus (Kunth) Mattf. & Kükenth. var. *nigritanus* (C.B. Cl.) Kükenth. in Engler, *Pflanzenr.* **4**, 20: 610 (1936).

Kyllinga alata (Nees) Hutchinson in Hutchinson and Dalziel, *Flora W. Trop. Afr.* **1**, 2: 487 (1936).

Kyllinga cristatus var. *exalatus* Merxm., *Proc. and Trans. of Rhod. Sc. Assoc.* **43**: 75 (1951).

Cyperus cristatus var. *exalatus* Merxm. *Trans. Rhod. Sc. Assoc.* **43**: 80 (1951).

K. alba var. *exalata* (Merxm.) Podlech, *Mitt. Staatssamml. Münch.* **3**: 525 (1960).

Plants tufted or forming a short row of sheathed stem-bases; sheaths brown, tough, frequently fibrous. *Culms* up to 520 mm tall, triangular, glabrous or minutely scabrid below inflorescence. *Leaves* numerous, flaccid, generally more than half length of culm; *sheaths* less than $\frac{1}{3}$ length of leaf; *blade* up to 5 mm wide, margin and keel scabrid especially in young leaves. *Inflorescence* of 1 (rarely 3) spikes, dense, globose to broadly elliptic, up to 15 mm in diam., snow-white or tinged with green or discoloured by rusty streaks. *Bracts* 2–5, usually 3, patent, later pendent, up to 121 mm long. *Spikelets* numerous, up to 6.37 mm long, ovate-lanceolate in outline, fertile glumes 2–4, rarely more than 2 fully developed, subtending 2 florets, both bisexual or upper male, rarely 3 (2 bisexual, uppermost male); lower glume strongly 7–11-nerved, keel excurrent into straight mucro up to 0.86 mm long; upper 5-nerved, keel scarcely or not at all excurrent into mucro. *Wing* to keel variable, absent, narrow (approximately 0.04 mm) or wide (up to 1 mm), glabrous or ciliate, white. *Anthers* 3. *Style* exceeded in length by

style branches. *Nut* 1, rarely 2, ellipsoid, shortly spiculate, half length of glume, golden, later red-brown to black.

S.W.A.—1713 (Swartbooisdrif): Okavango Territory, S of Omuramba (-AD), *de Winter* 3884 (PRE).

—1719 (Runtu): Vlei near Runtu (-DD), *Merxmüller & Giess* 2135 (M).

—1729 (Sambio): East of Masare Camp (-CC), *de Winter & Wiss* 4100 (M, PRE).

—1917 (Tsumeb): 50 miles W of Grootfontein (-BC), *Schoenfelder* 35 (PRE).

—1918 (Grootfontein): Grootfontein (-CA), *Story* 6131 (PRE).

—2115 (Karibib): on way to Red Koppies at Karibib (-DD), *Kinges* 3193 (M, PRE).

—2217 (Windhoek): Farm Otjisewa (-CA?) *Wiss* 755 (M); Farm Onduno (-CA?) *Kinges* 4959 (M).

TRANSVAAL—2231 (Pafurie): Kruger National Park S.E. of Punda Milia (-CA), *Schieben* 9525 (M).

—2329 (Pietersburg): Pietersburg (-CD), *Codd and Dyer* 9157 (PRE); Haennertzburg (-DD), *Pott* 4751 (PRE).

—2330 (Tzaneen): Woodbush (-CC), *Mogg* 14716 (PRE).

—2427 (Thabazimbi): Rustenburg district, Vlakfontein (-AB), *Liebenberg* 158 (PRE).

—2428 (Nylstroom): Nylstroom (-CB), *van Dam s.n.* (PRE); Naboomspruit (-DA), *Galpin* M375 (PRE).

—2429 (Zebediela): Schoonoord, Lydenburg district, (-DD) *Mogg and Barnard* 794 (PRE).

—2430 (Pilgrims Rest): Pilgrims Rest (-DD), *de Winter and Codd* 539 (PRE).

—2431 (Acornhoek): Skukuza (-DC), *de Winter and Codd* 538 (PRE).

—2527 (Rustenburg): Rustenburg (-CA), *Lanham* 25 (PRE).

—2528 (Pretoria): Onderstepoort (-CA), *Teiler* 14805 (PRE); Pretoria, *Leendertz* 7211 (PRE); do. *Stent* 573 (PRE); do. *Bryant* E2 (PRE); do. Sloff's Cutting, *Smith* 177, 822 and 861 (PRE); Bronkhorstspuit (-DC), *Pepton* 4703 (PRE).

—2531 (Komatipoort): Pretoriuskop, Kruger National Park (-AB), *van der Schijff* 1071 (PRE).

—2626 (Klerksdorp): Lichtenburg district, Hakbaslaagte (-AC), *Kinges* 1520 (PRE, M).

—2627 (Potchefstroom): Welverdiend (-AD), *Louw* 98 (PRE); Potchefstroom (-CA), *Louw* 1167 (PRE).

—2628 (Johannesburg): Turffontein (-AA), *Bryant* D50 (PRE); Heidelberg (-AD), *Leendertz* 8012 (PRE).

—2725 (Bloemhof): Christiana (-CC), *Theron* 432 (PRE); Bloemhof (-DA), *Burt* *Davy* 11242, 12838, 14438 (PRE), *van der Merwe* 58 (PRE).

ORANGE FREE STATE—2727 (Kroonstad): Kroonstad (-CA), *Pont* 495 (BLFU, PRE).

—2926 (Bloemfontein): Bloemfontein (-AA), *Potts* 407 (NU), *Potts* 3031 (NU, PRE), *Potts* 1326 (NU), *Potts* 3006, 3009, 3022 (BLFU); Channon (-AB), *Hatchard* 7328 (BLFU).

—3025 (Colesburg): Trompsburg (-BB), *Potts s.n.* (BLFU).

—3027 (Lady Grey): Pan near Quaggafontein (-AC), *Potts* 3006 (BLFU).

SWAZILAND—2531 (Komatipoort): Hlatikulu district, Havelock Concession (-CC), *Saltmarsh* 1021 (PRE).

—2631 (Mbabane): Forbes Reef Swamp (-AA), *Compton* 30564 (PRE, HSS); Komati Pass, Mbabane (-AC), *Compton* 31048 (HSS); Hlatikulu, (-CD), *Stewart s.n.* (PRE).

NATAL—2632 (Bela Vista): Ndumu Hill (-CD), Ross 675 (NU); Ndumu Game Reserve, Ross 685, 693 (NU).

—2732 (Ubombo): Summit of Lebombo Mountains (-AA, -AC), Getliffe 178 (NU); Ubombo Village (-CA), Ward 1656 (NPGF, NU, PRE), Getliffe 162 (NU).

—2929 (Underberg): Warley Common (-BB), Mogg 7248 (PRE).

LESOTHO—2828 (Bethlehem): Caledon River, Burke 202 (PRE), Dieterlen 334 (PRE, NH).

CAPE—2624 (Vryburg): Vryburg (-DC), Sharpe 7420 (PRE); do. Mogg 8170 (PRE); Vryburg and Tiger Kloof, Brueckner 2831 (PRE); 60 miles from Vryburg (Farm Palmyra), Rodin 3598 (PRE).

—2723 (Kuruman): Kuruman, Esperanza (-AD), Esterhuysen 2143 (PRE).

—2823 (Griekwastad): Postmasburg (-AC), Leistner 1662 (PRE); Daniel's Kuil (BA), Esterhuysen s.n. (PRE).

—2824 (Kimberley): Kimberley (-DB), Moran s.n. (PRE).

K. alba is a widespread tropical and temperate species with which have been associated several allies. In the course of this study, each of these allied taxa was compared with *K. alba*.

Closely allied to *K. alba*, according to many authors (Clarke, 1901; Brain, 1934; Kükenthal, 1936 and Robinson, 1959), is *K. controversa* Steud. The original descriptions of these two species differ only in the statement that *K. controversa* has two stamens but Clarke (1901) remarked on the pale brown inflorescence, ciliate keelar wing and short spikelets. Studies of wing width have revealed considerable variation within *K. alba* and considerable overlap in range of this and allied taxa (Figure 10). This does not support the separation of *K. alba* and *K. controversa* on the basis of wing width. All specimens examined, whether tropical or southern African, had three stamens. Nor does the spikelet length, with ranges of 3,08 (av. 3,72) – 5,40 mm for *K. alba*, and 3,67 (av. 4,3) – 6,25 mm for *K. controversa* separate these two. *K. controversa* has therefore been placed in synonymy with *K. alba*.

K. nigriflora C. B. Clarke was distinguished by its pale cinnamon-coloured, broadly ovate winged spikelets. Podlech (1960) regarded it as a variety of *K. alba*. Comparison of specimens seen by Podlech with authentic *K. alba* specimens, suggests that the colour difference was the result of rusty streaks or dots similar to those found in gatherings of *K. alba* from dry localities (Moran 1918, Sharpe 7420, Rodin 3598). In every other respect, these two taxa appear identical. Similarly, *K. alba* var. *exalata* is not upheld in view of the variation in wing width over the range of distribution and with age.

Robinson (1959) suggested that *K. cartilaginea* Schum. was closely allied to *K. alba*. Kükenthal (1936) maintains it as a distinct species. Further study of this tropical species is necessary, but two characteristics suggest it is a separate species: the presence of an extremely long mucro on the lower fertile glume giving the heads "a prickly look" (Robinson, 1959) and the very dis-

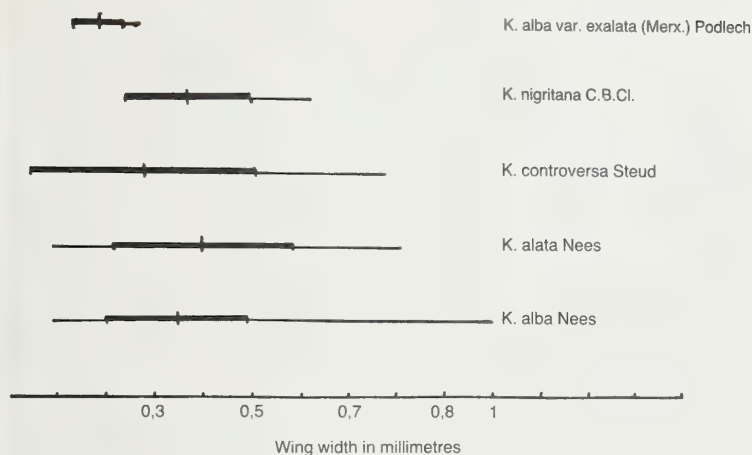


FIG. 10

Mean wing width (M), standard deviation from the mean (heavy line) and range of wing width (narrow line) from representative samples of *K. alba* and associated taxa.

tinct rhizome morphology as evident in *Napper 1371* (Herb. EARO) in which aerial shoots are 30–40 mm apart on an elongated rhizome.

K. alba is therefore recognized as a complex, variable species with tropical affinities. It is a distinctive tufted species with globose white spikes sometimes tinged with cinnamon in drier areas. It is unlikely to be confused with any other South African species.

As described above, it is distinguished from *K. cartilaginea* by rhizome characters. *K. platyphylla* Schum., collected rarely in Zimbabwe but frequently in Zambia and Tanzania, is similar but has broad flattened hemispherical heads composed of three confluent spikes clasped by 3–4 bracts.

9. ***K. brevifolia*** Rottb., Descr. et Icon. 13, t.4, fig. 3 (1773); Nees in Wight, Contrib. Bot. India 91 (1834); Kunth, Enum. Pl. :130 (1837); Steud., Synops Cyper. 67 (1855); Boeck. in Linnaea 35: 424 (1868); p.p.; Clarke in Hooker, Fl. Brit. India 6: 588 (1893), in Durand and Schinz, Conspect. Fl. Afr. 5: 527 (1895), in Thiselton-Dyer Fl. Trop. Afr. 8: 273 (1901) and in Illustr. Cyp. t. I Fig. 1–4 (1909); Chermeson, Catal. Pl. Madag. 7 (1931), Barros, in Anal. Mus. argent. Cienc. Natur.: 136f.l.: 11 (1935) Hooper, in Hepper, Flora W.Trop.Afr. ed 2,3, 2:307 (1972). Type: India, *Koenig* (BM, holo.!, STB, iso., photostat seen).

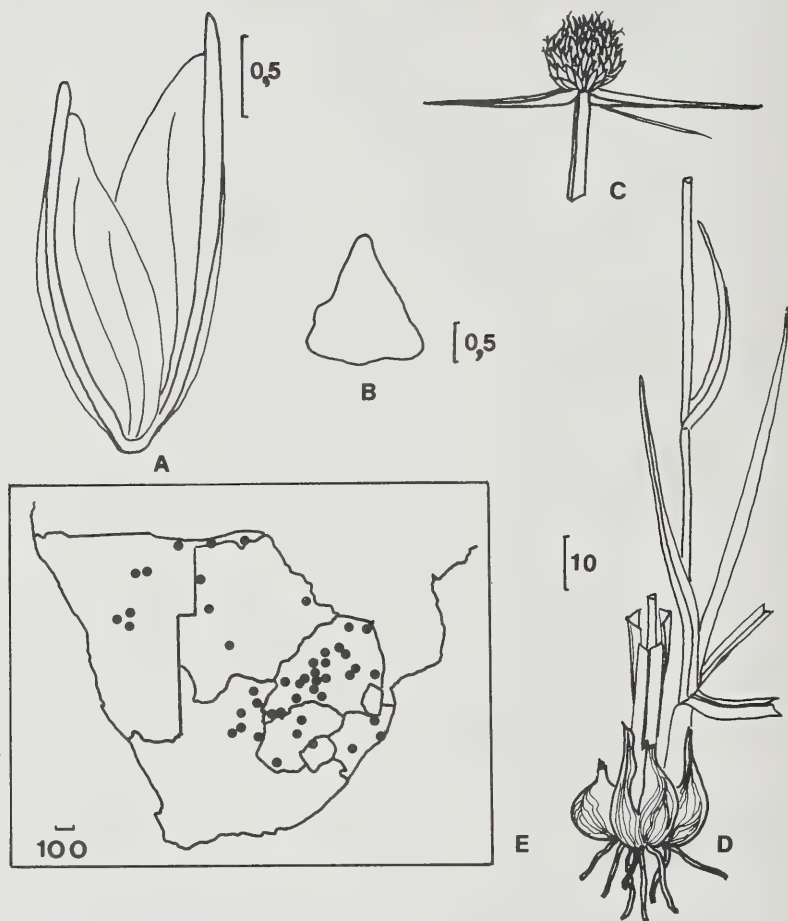


FIG. 11

Morphology and distribution of *K. alba*. A. Fertile glumes of spikelet with narrow wings on the keels. B. Cross-sectional outline of stem. C. Inflorescence. D. Group of stem-bases. E. Distribution of the species in southern Africa. Figure scales in millimetres; map scales in kilometres.

Cyperus brevifolius (Rottb.) Hassk., Kükenth., in Engler, Pflanzenr., 20:600 (1936).

K. cruciata Nees in Linnaea 9: 286 (1834), name only.

Rhizome slender (1–2½ mm diam.), elongate, white or greenish-white, covered with membranous, striate scales. *Culms* 5–30 mm apart, slender, 7–32 mm tall, triangular, glabrous, bases unthickened. *Leaves* few, equaling or shorter than culms; sheaths membranous, lower 1–2 leafless or briefly laminate; blades 1–3 mm wide, margins and keel scabrid, shortly acuminate. *Bracts* 3–4, long, erect, later spreading. *Inflorescence* of 1 spike (rarely 2 or 3), ovoid to ellipsoid, greenish-white, dense. *Spikelets* numerous, tightly packed, elliptic in outline, 2–3.5 mm long; floret 1, bisexual, rarely 2, lower bisexual, upper male. *Fertile glumes* 2, membranous, transparent white, lower 7-nerved, upper 3–5-nerved, keel green, scabrid, excurrent into acute recurved mucro (0.2–0.45 mm). *Stamens* 1 per floret. *Style* short, far exceeded in length by style branches. *Nut* ½ length of glume; broadly obovate, yellow.

NATAL—2930 (Pietermaritzburg): Vlei in Pietermaritzburg (-CB), Thurgood s.n. (NU); Chase Valley, Getliffe 23 (NU); Wyllie Park, Ross 357, 358 (NU); University of Natal, Getliffe 191, 228 (NU); Botanical Gardens, Ross 1266 (NU); Golf Road, Pietermaritzburg, Ross 1267 (NU); King Edward Avenue, Getliffe 998, 999 (J); Thomas Moore School, Pinetown (-DD), Getliffe 1003 (J); Edgewood Training College, Pinetown, Getliffe 1007 (J).
—2931 (Stanger): Jameson Park (-CC), Hilliard s.n. (NU); Windsor Park Golf Course, Getliffe 976 (J).

Although it appears, as *K. erecta*, in Henderson and Anderson (1966) as a weed in South Africa, there has been no other record of this species from southern Africa until the present study. It has, however, been well recorded for west tropical Africa (Clarke, 1901; Hutchinson, 1936; Hooper, 1972b). The possibility of this frequent weed of lawns being an introduction cannot be dismissed.

There appears to be some confusion in the older descriptions over the stamen number. Linnaeus in his *Species Plantarum* placed it among plants with three stamens. Kunth (1837) agreed but Barros (1935) working on South American material recorded one stamen only per floret. Kükenth (1936) gave a range of 1–3. Either this is an extremely variable taxon, or several distinct taxa have been confused in the description. South African specimens have but a single stamen per floret.

Apart from this distinctive feature, it is recognized by its slender white rhizomes (without the striking red-brown scales of *K. intricata*) and its greenish-white ovoid to ellipsoid spikes. It cannot be confused with *K. erecta* which has a fleshy rhizome and contiguous, bulbous-based stems.

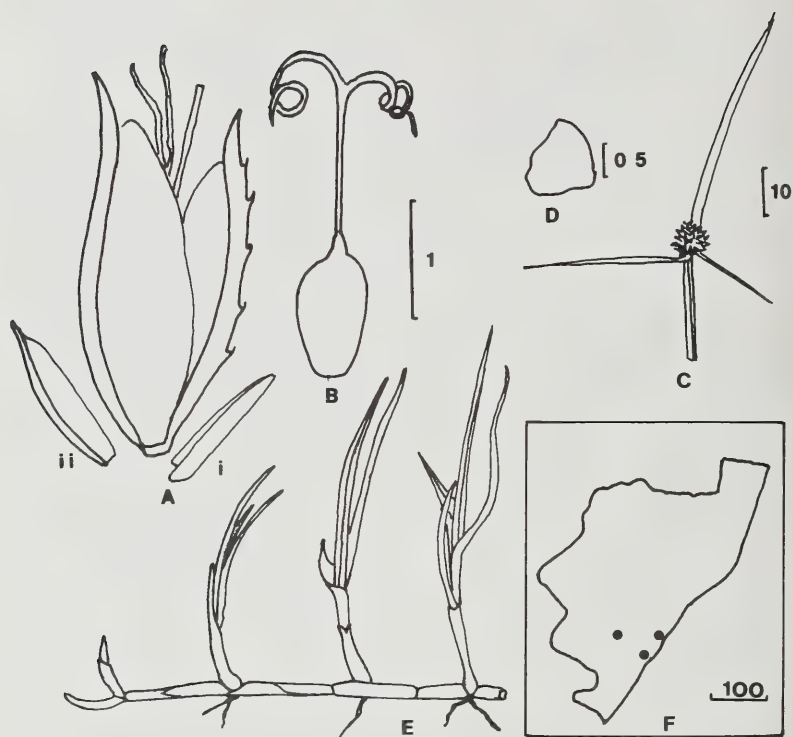


FIG. 12

Morphology and distribution of *K. brevifolia*. A. Spikelet with lower sterile bract (i); and prophyll or empty glume (ii) and two glumes enclosing 1 floret with a single stamen. B. Young nutlet. C. Inflorescence with one erect bract and two smaller spreading bracts. D. Cross-sectional outline of stem. E. Portion of slender elongated rhizome. F. Distribution of the species in Natal. Figure scales in millimetres: map scale in kilometres.

10. *K. elatior* Kunth, Enum. Pl. 2: 135 (1837); Steud., Synops. Cyper. 69 (1855); Boeck in Linnaea 35: 422 (1868); C. B. Clarke, in Durand and Schinz, Conspect. Fl. Afr. 5: 528 (1895), in Thiselton-Dyer, Fl. Cap. 7: 153 (1897), in Thiselton-Dyer, Flora Trop. Afr. 8: 275 (1901) and in Kew Bull. Add. Ser. 8: 93 (1908); Medley Wood in Trans. S.A. Phil. Soc. 2: 250 (1908); Chermexon, Catal. Pl. Madag. 7 (1931); Hooper in Hepper, Flora W. Trop. Afr. ed 2, 3, 2:307 (1972). Type: South Africa, Pondoland. *Drège* 4384 (B, holo., possibly destroyed; P, iso.).

Cyperus aromaticus (Ridl.) Mattf. et Kükenth. var. *elator* (Kunth) Kükenth. in Engler, Pflanzenr. 4, 20:582 (1936).

Roots thick. *Rhizome* elongated, horizontal, slender (2–3 mm diam.), pliable, covered with acuminate, striate scales with transparent membranous margins. *Stem-bases* scarcely thickened, covered with scales and pinkish-brown sheaths. *Culms* 150–600 mm tall, triangular, distant, 3–22 mm apart, average 17 mm apart, glabrous. *Leaves* few, shorter than culms, lower leaves reduced to sheaths, upper 2–4 sheaths laminate; sheaths membranous, pinkish-brown, frequently transversely wrinkled below mouth; blades 2–6 mm wide, scabrid on margins and keels and on lower leaf surface, particularly near tip. *Bracts* 4–6, spaced at short intervals below inflorescence, up to 290 mm long, spreading at right angles to culms. *Inflorescence* of 3–1 green spikes, dense; central spike cylindric, 7–20 mm long, 5–13 mm wide; lateral smaller. *Spikelets* numerous 2.7–4.5 mm long, ovate-lanceolate in outline; fertile glumes 3; lower glume 7-nerved, subtending bisexual floret, middle 5-nerved, subtending male (rarely bisexual) floret; keels green, wingless, glabrous or with 1–4 hairs, excurrent into slender, acuminate, recurved mucro, 0.28–0.59 mm long. *Stamens* 3, anthers linear, connective slightly produced and red. *Style* greatly exceeded in length by branches. *Nut* (rarely 2), obovoid, approximately 1 mm long, red-brown, later black.

NATAL—2831 (Nkandhla): Ngoye Forest Reserve, streambank (-DC), *Getliffe* 215 (NU); Qwesqweqneqnolo, Ngoye Forest Reserve, *Getliffe* 217 (NU); Forest Guard Hut, Ngoye Forest Reserve, *Getliffe* 220 (NU); Mtunzini, Port Durnford Forester's Office (-DD), *Getliffe* 214 (NU).

—2832 (Mtubatuba): Richards Bay (-CC), *Ward* 714 (NU); do. *Getliffe* 60 (NU).

—2930 (Pietermaritzburg): Lions River district, "The Start", Karkloof (-AD), *Getliffe* 205 (NU); Town Bush Valley, Pietermaritzburg (-CB), *Ward* 118 (NU); do. *Getliffe* 196 (NU); Table Mountain, *Killick* 375 (NU, PRE); Chase Valley, Pietermaritzburg, *Jolliffe* 34 (NU); do. *Wilson* 11 (NU); do. *Getliffe* 25 (NU); do. *Ross* 728 (NU); Enon Estate, Richmond (-CD), *Getliffe* 165 (NU); Nagle Dam (-DA), *Wells* 1021 (NU); Ichanga (-DC), *Armour s.n.* (NU); Isipingo Flats (-DD), *Ward* 4961 (NU); Wentworth, relict of Bayhead Swamps (-DD), *Ward* 4971 (NU).

—2931 (Stanger): Farm Waterbosch, Stanger (-AD), *Bodhoo s.n.* (NU); Stanger Secondary School, *Getliffe* 226 (NU); Inanda district, Mount Edgecombe (-CA), *McMartin* 9 (NU); do. *Getliffe* 201 (NU);

—3030 (Port Shepstone): Isipingo Beach (-BB), *Ward* 4065 (NU); do. *Ward* 4968 (NU); Sezeta River (-BC), *Getliffe* 31 (NU); Glenmore, Port Shepstone district (-CD), *Anderson* 55 (PRE).

CAPE—3129 (Port St. Johns): Port St. Johns district (-DA), *Schonland* 4162 (PRE).

—3227 (Stutterheim): NW of Zele P.O., King Williamstown (-CD), *Acocks* 20279 (PRE, SRGH).

This elegant species with long horizontal bracts and elongate slender rhizomes bearing culms at wide intervals occurs in damp shady situations where

it may form dense stands. The inflorescence is a cylindrical spike borne on acutely three-angled stems. Not only is the rhizome fragrant but the aerial parts are delicately lemon-scented when bruised. A mat, possibly for carrying maize meal and known as "isitebe", is made from these culms (Medley Wood, 1908).

K. elatior is unlikely to be confused with any other South African species but the description in Brain (1934) is misleading being based on an incorrectly named gathering of *K. melanosperma*. The long bracts and elongate rhizome are reliable features distinguishing these species; similarly the congested rhizome of *K. polyphylla* and its composite inflorescence of globose spikes distinguishes this from *K. elatior*.

11. *K. intricata* Chermezon, in Bull. Mus. Hist. Nat (Paris) **25**: 211 (1919); Catal. Pl. Madag. 8 (1931); Podlech in Prodr. Fl. Südwestafr. **165**:31 (1967). Type: Madagascar, *Hildebrandt 3788* (K, holo.).

K. erecta var. *intricata* C. B. Clarke in Durand and Schinz, Conspect. Fl. Afr. **5**: 529 (1895).

Cyperus erectus (Schum.) Mattf. and Kükenth. var. *intricatus* (C. B. Clarke) Kükenth. in Engler, Pflanzenr. **4** (20): 590 (1936).

Rhizome elongate, slender, 1–2 mm diam., horizontal, covered with loose, red-brown scales. *Culms* 5–(15)–30 mm apart, bases not thickened. *Leaves* 2–9 per culm, shorter than culms. *Bracts* 3, lowest erect, later reflexed. *Inflorescence* 1 globose spike 4–8 mm wide, compact golden-buff. *Spikelets* many, ovate—lanceolate in outline, 2–4 (av. 2.97) mm long. *Fertile glumes* 2 or 3, briefly mucronate, lower mucro av. 0.18 mm, upper 0.13 mm. *Style* shorter than branches. *Nut* 1, less than half length of glume, ellipsoid to obovoid, yellow to black.

S.W.A.—1719 (Runtu): Okavango Reserve (-DD), *de Winter 3744* (M, PRE). —1821 (Andara): Caprivi Zipfel, Andara (-AB), *Merxmüller & Giess 1977* (M); E Caprivi (-AB?), *Killick & Leistner 3034* (PRE).

TRANSVAAL—2528 (Pretoria): 15 km from Hammanskraal (-AD), *Kies 374* (PRE); do. *Codd 3512* (PRE).

NATAL—2931 (Stanger): Verulam (-CA), *Medley Wood 1076* (NH).

K. intricata is a tropical species with limited distribution in South Africa. It is allied to *K. erecta* but its distinctive rhizome with elongated internodes and loose overlapping scales distinguish it from that species. The mucro length in *K. intricata* is distinctly shorter than that of *K. erecta*, spikelets are also smaller on an average but the ranges overlap making this less valuable than rhizome and mucro features.

12. *K. erecta* Schumach. in Schum. et Thon., Besk. Guin. Pl. 63 (1827); C. B. Clarke in Durand and Schinz, Conspect. Fl. Afr. **5**: 528 and in Thiselton-

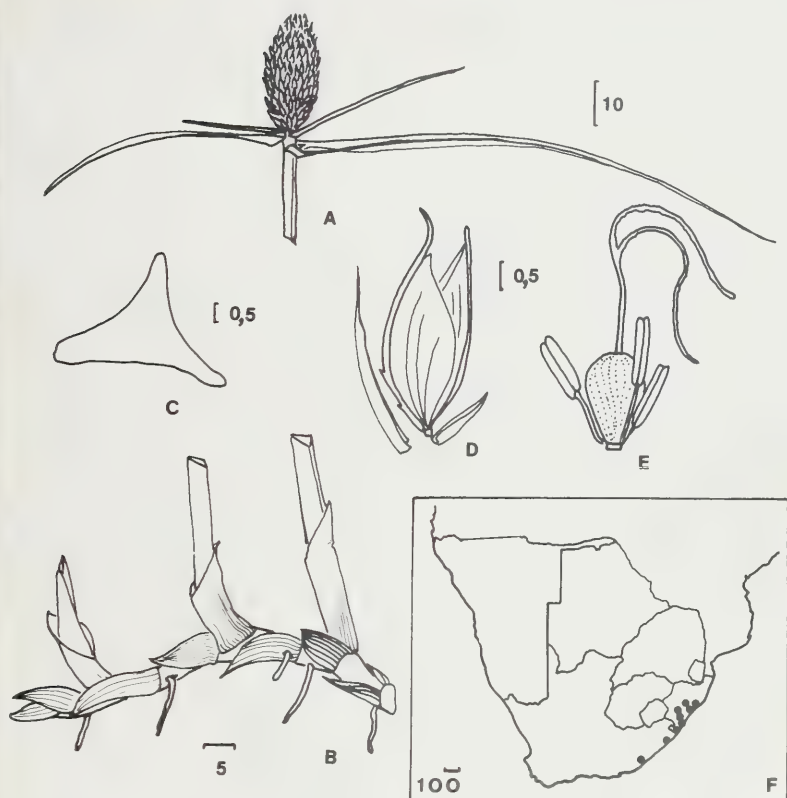


FIG. 13

Morphology and distribution of *K. elatior*. A. Inflorescence subtended by long spreading bracts. B. Robust elongated rhizome clothed in striate scales. C. Cross-sectional outline of culm. D. Spikelet with lower empty glumes (bracts and prophyll) and two fertile glumes. E. Floret from within fertile glumes. F. Distribution in southern Africa. Figure scales in millimetres: map scale in kilometres.

Dyer, *Flora Trop. Afr.* 8:274 (1901); Rendle, in *Catal. Afr. Pl. Welw.* 2: 105 (1899); Medley Wood, in *Trans. S.A. Phil. Soc.* 18, 2: 250 (1908); Schonland, in *Mem. bot. Surv. S. Afr.* 3: 20 t11 (1922); Chermeson, *Catal. Pl. Madag.* 7 (1931), Hutchinson in Hutchinson and Dalziel, *Flora W. Trop. Afr.* 2, 2: 487 (1936); Nelves and Baldwin, in *Amer. Journ. Bot.* 39: 389 (1952); Hooper in Hepper, *Flora W. Trop. Afr.* ed 2, 3, 2: 307 (1972). Type: Guinea, *Isert and Thonning* (C).

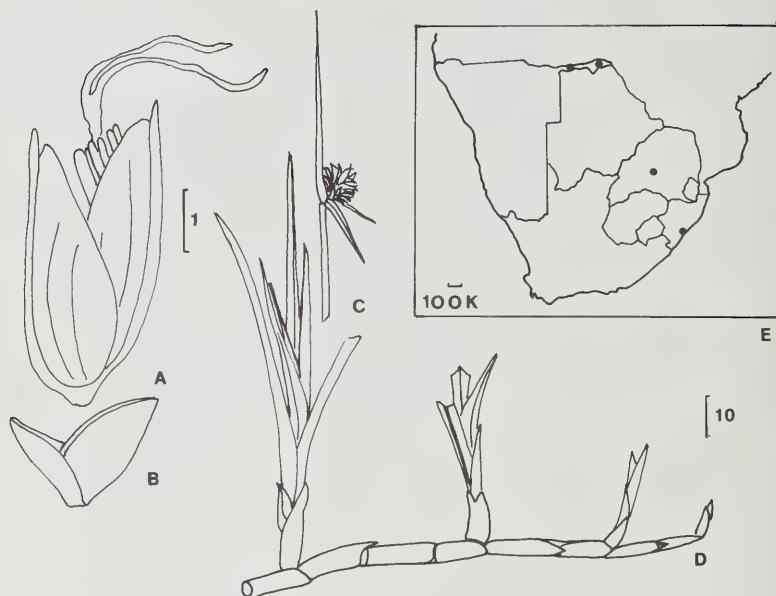


FIG. 14

Morphology and distribution of *K. intricata*. A. Spikelet including empty lower glumes (B). C. Inflorescence with one erect bract. D. Portion of rhizome clothed in loose brown scales. E. Distribution in southern Africa. Figure scales in millimetres: map scale in kilometres.

K. aurata Nees in *Linnaea* **10**: 139 (1935–36), Kunth, *Enum. Pl.* **2**: 137 (1837), Steud., *Synops Cyp.* 69 (1855), Boeck. in *Linnaea* **35**: 422 (1868), Ridl. in *Trans. Linn. Soc.* **2** ser. Bot. **2**: 146 (1884).

K. colorata Hutchinson, in Hutchinson and Dalziel, *Flora W. Trop. Afr.* **2**, **2**: 487 (1936) (non (L.) Druce).

Cyperus erectus (Schum.) Mattf. and Kükenth. in Engler, *Pflanzenr.* **4**, **20**: 588 (1936).

C. erectus var. *aurata* (Nees) Kükenth. in Engler, l.c. 589 (1936).

Rhizome moderately long, of bulbous stem-bases. internodes short, clothed in acuminate, red-brown, seldom overlapping, scales. *Culms* produced in uniseriate row, slender, triangular to rounded, glabrous, bases bulbous, thickened. *Leaves* few, shorter than culms; sheaths short, lowest 2–3 leafless, red-brown, blade flat, 2–3 mm wide, flaccid, acuminate. *Bracts* 3, lowest erect, later reflexed. *Inflorescence* of 1 spike, globose to ovoid, 4–8 mm wide, compact, greenish-yellow to red-golden. *Spikelets* many, ovate-

lanceolate in outline, 2–3 mm long, fertile glumes 2 or 3 golden, frequently rust-streaked, lowest prominently 7–9-nerved, subtending bisexual flower, middle 3–5-nerved, subtending male flower, sometimes enclosing reduced hyaline uppermost empty glumes, keels green when fresh, glabrous or with 1–2 scabrid hairs, excurrent into acute recurved mucro 0.2–0.5 mm long (average length of lower mucro 0.35 mm). *Style* exceeded in length by style branches. *Nut* 1, less than $\frac{1}{2}$ length of glume, ellipsoid to obovoid, yellow to black.

TRANSVAAL—2530 (Lydenburg): Machadodorp (-CB), *de Winter and Codd* 227 (PRE).

—2531 (Komatipoort): Pretoriuskop (-AB), *van der Schijf* 1999 (PRE).

—2626 (Klerksdorp): Hakboslaagte (-AC), *Kinges* 1648 (PRE).

—2627 (Potchefstroom): Potchefstroom district, Laerberg (-CA), *Theron* 686 (PRE); Potchefstroom, *Louw* 1216 (PRE).

—2628 (Johannesburg): Frankenwald (-AA), *Gilliland* 25059 (PRE).

—2629 (Bethal): Ermelo (-DB), *Leendertz* 10539 (PRE); Noodgedacht, *Potter* 1781 (PRE).

ORANGE FREE STATE—2828 (Bethlehem): Bethlehem (-AB), *Phillips* 3102 (PRE).

NATAL—2632 (Bela Vista): Ndumu Game Reserve (-CD); *Ross* 659, 687, 694 (NU).

—2732 (Ubombo): False Bay Park (-CD), *Ward* 4144 (PRE).

—2832 (Mtubatuba): Hluhluwe Game Reserve (-AA), *Ward* 1793 (NH, NPGF, NU, PRE); St. Lucia Park (-AD), *Dutton* 62 (NU).

—2930 (Pietermaritzburg): New Hanover, Fawnleas (-BC), *Getliffe* 170 (NU); Town Bush Valley (-CB), *Ward* 110 (NU); Oribi, *Evans* 17 (NU); Thomas Moore School (-DD), *Getliffe* 176 (NU).

—2931 (Stanger): Mount Edgecombe (-CA) *Most* 77 (NU).

CAPE—2624 (Vryburg): Moita, Mafikeng District (-BB), *Brueckner* 554 (PRE).

—3326 (Grahamstown): Grahamstown (-BC), *Daly & Sole* 202 (PRE); Trappes Valley, *Daly* 12934 (PRE); do. *Lubke* 88 (NU); Alexandria District near Whitney (-DA), *Archibald* 5068 (PRE).

—3327 (Peddie): between Core Rock and Gooda River (-BB), *Galpin* 7355 (PRE).

—3420 (Bredasdorp): Heidelberg (-BB), *Esterhuysen* 14455 (PRE).

Kyllinga erecta Schum. and *K. aurata* Nees were regarded as synonyms by Clarke (1897) and Schonland (1922), but Kükenthal recognized them as two varieties of *Cyperus erectus*. He distinguished the variety *aurata* by its golden to rust forms, shorter culms, narrower leaves and longer mucronate tips to the keel of the glumes.

Height of the plant cannot be regarded as diagnostic as it is so dependent upon environmental conditions and indeed *Dieterlen* 211 (which Kükenthal cites as the variety *aurata*) exceeds his 200 mm limit for *C. erectus* var. *auratus*. Leaf-width has been shown to be unreliable and no significant difference in mucro length could be detected.

In the more southerly collections the colour of the head appears to be prominently golden but in the absence of any clear-cut distinction it is proposed that *K. erecta* and *K. aurata* are conspecific.

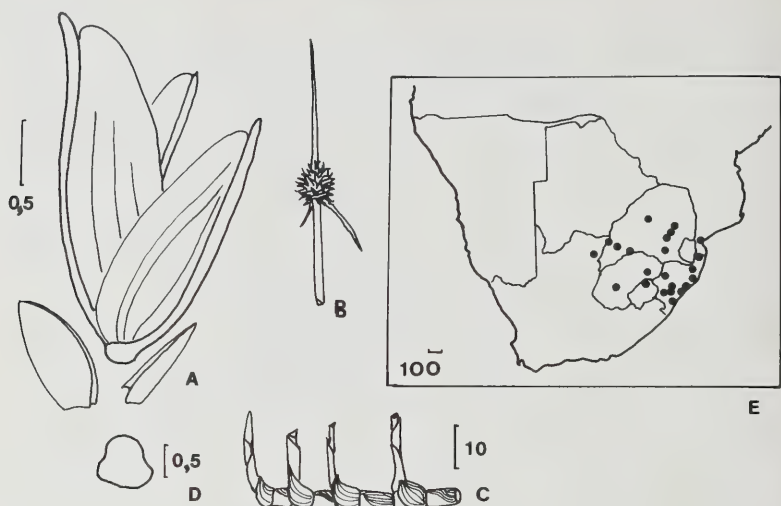


FIG. 15

Morphology and distribution of *K. erecta*. A. Whole spikelet. B. Inflorescence with erect bract. C. Rhizome comprising short swollen internodes with bulbous-based shoots not contiguous. D. Cross-sectional outline of culm. E. Distribution of species in southern Africa. Figure scales in millimetres: map scale in kilometres.

13. *K. melanosperma* Nees in *Linnaea* **9**: 286 (1834) name only, in Wight, *Contributions to the Bot. of India*, 91 (1834); Kunth, *Enum. Pl.* **2**: 131 (1837); Steud. *Synops. Cyper.* 67 (1855); Boeck. in *Linnaea* **35**: 419 (1868); Oliver in *Trans. Linn. Soc.* **29**: 166 (1875); C. B. Clarke, in *Hooker Fl. Brit. India* **6**: 588 (1893), in Durand and Schinz, in *Thiselton-Dyer, Flora Cap.* **7**: 153 (1897), in *Thiselton-Dyer, Flora Trop. Afr.* **8**: 277 (1901) and in *Bull. Misc. Inf. Add. Ser.* **8**: 93 (1908); Medley Wood, in *Trans. S.A. Phil. Soc.* **17**, 2: 250 (1908); Burt Davy & Pott-Leendertz, in *Ann. Trans. Mus.* **132** (1912); Schonland in *Mem. bot. Surv. S. Afr.* **3**: 20 (1922); Dyer, in *Rec. Albany Mus.* **470** (1927); Fourcade in *Mem. bot. Surv. S. Africa* **20**: 85 (1941); Hooper in *Hepper, Flora W. Trop. Afr.* ed 2, **3**, 2: 307 (1972). Type: India, *Wight 1851* (K, holo.).

Cyperus melanospermus (Nees) Kükenth. in *Engler, Pflanzenr.* **4**, 20: 583 (1936).

Roots thick. *Rhizome* horizontal, stout (4–8 mm diam.), congested (internodes 3–5 mm) covered with short red-brown, acuminate, imbricate scales with hyaline margins. *Stem-bases* bulbous-thickened, covered with cuspidate scales. *Culms* 150–1 000 mm tall, firm, triangular, glabrous, con-

gested, in uniseriate rows or massed in groups. *Leaves* few, lower leaves reduced to red-brown membranous sheaths, upper 2–4 sheaths shortly laminate; sheaths long, mouth of sheath often membranous and transversely wrinkled; blade 3–4 mm wide, flat, scabrid on margins and keels, stiff. *Bracts* 3 or 3 plus 1 very small bract, relatively short (up to 120 mm), upright, later reflexed, stiff. *Inflorescence* a single spike, ovoid-cylindric to subglobose, 5–14 mm long by 6–10 mm wide, dense golden-green (rust-coloured under unfavourable conditions). *Spikelets* numerous, ovate-lanceolate in outline, 3–5.5 mm long (average length 3.97 mm), fertile glumes 2, unequal, plus third upper reduced hyaline empty glume, lower glume 7-nerved, subtending bisexual floret, middle 5-nerved, subtending male, rarely bisexual floret; keels green, wingless, glabrous or sparsely scabrid, excurrent into slender, acuminate, slightly recurved mucro (0.25–0.70 mm long). *Stamens* 3, anthers linear, connective slightly produced and red. *Style* far exceeded in length by style branches. *Nut* 1 (rarely 2), small (approximately 1 mm long), obovoid, golden turning bright red-orange later black, slightly apiculate.

BOTSWANA—2525 (Mafikeng): Kanye district, source of Ramongola river (-AB), *Hilliary and Robertson* 576 (PRE).

TRANSVAAL—2288 (Maasstrom): 2 miles E of Donderhoek (-DD), *Killick* 1533 (NU).

—2329 (Pietersburg): Haenertsburg (-DD), *Pott* 13641 (PRE).

—2330 (Tzaneen): Westfalia estate, Duiwelskloof (-CA), *Scheepers* 167 (PRE); Magoesbaskloof (-CC), *Winter & Codd* 135 (PRE); do. *Codd* 3076 (PRE); Tzaneen, *Phillips* 3285 (PRE).

—2428 (Nylstroom): Warmbaths (-CD), *Leendertz* 6199 (PRE).

—2527 (Rustenburg): Rustenburg (-CA), *Leendertz* 3428 (PRE).

—2528 (Pretoria): Aapies River (-CA), *Leendertz* 6216 (PRE); Pretoria, *Repton* 734 (PRE).

—2529 (Witbank): near Groblersdal (-AB), *Acocks* 20901 (PRE).

—2530 (Lydenburg): Waterfall (-CB), *Rogers* 14398 (PRE).

—2531 (Komatipoort): Nelspruit (-AD), *Breyer* 17978 (PRE); Pretoriuskop, *van der Schijff* 1981 (PRE).

—2627 (Potchefstroom): Krugersdorp, Farm Gladysvale (-BB), *Rodin* 3921 (PRE).

—2628 (Johannesburg): Rietvallei Farm, Johannesburg (-AA), *Mogg* 14769 (PRE); Frankenwald, *Rose Innes* 7 (PRE).

—2630 (Carolina): Marimstad (-CA), *Pott* 5226 (PRE).

SWAZILAND—2631 (Mbabane): Black Mbuluzi Valley Swamp (-AA?), *Compton* 28258 (PRE); Marikiana Swamp (-CA), *Compton* 28460 (HSS, PRE); near Hlatikulu on Goedegun Road (-CD), *Ross* 1477 (NU).

—2731 (Louwsberg): Goedegun (-AA), *Ross* 1430 (NU).

NATAL—2730 (Vryheid): Pongola River (-AD), *Getliffe* 285 (NU); on Louwsberg Road near Vryheid (-DD), *Getliffe* 283 (NU); do. *Ross* 1212 (NU); do. *Ross* 1216 (NU).

—2830 (Dundee): Klip River District, near Wessels Nek (-AC), *Pentz and Acocks* A10269 (PRE); near Nqutu on Qudeni Road (-BA), *Edward* 2190 (PRE); Mtunzini, Hamewith (-CC), *Mogg* 6028 (PRE).

—2929 (Underberg): Estcourt district, Blaauwkrantz River (-BB), *Getliffe* 267 (NU); Bergville (-CD), *Edwards* 2357 (PRE).

—2930 (Pietermaritzburg): Lidgetton (-AC), *Mogg* 801 (PRE); Karkloof, *Gordon-Gray s.n.* (NU); Howick, *Getliffe* 223 (NU); Albert Falls (-AD), *Dement* 28 (NH, NU); Town Bush Valley, *Getliffe* 309 (NU); Greytown (-BA), *Medley Wood* 641 (NH), *Getliffe* 223 (NU); Lilani (-BB), *Hilliard s.n.* (NU); Hermannsburg, *Getliffe* 173 (NU).

—2931 (Stanger): flats near Durban (-CC), *Medley Wood* 4100 (NH).

—3030 (Port Shepstone): near Umtamvuna Pont (-CC), *Getliffe* 30 (NU).

District unknown: Kumbula Mission Station, *Gerstner* 4333 (PRE).

CAPE—3227 (Stutterheim): Stutterheim (-CB), *Acocks* 9240 (PRE).

K. melanosperma has been widely collected in southern Africa no doubt partly because it is conspicuous in the field forming dense stands near water. The species may be recognized by its stout congested rhizomes and the cylindrical head subtended by short bracts which reflex from erect position to an angle of 45° from the culm when older.

Gerstner, in notes accompanying his specimen number 4333 (from Kwa-Zulu), mentioned that culms were used by the Zulus to make “in Xosahne” a sieve for native beer. Grant (in Oliver, 1875) described *K. melanosperma* as a “sweet smelling plant”, the roots of which were pounded by Wezee women and rubbed on their skin as a scent. Their name for this species is “Keetolo” (Grant, l.c.).

Schonland (1922) pointed out that Clarke (1901) distinguished inadequately between *K. melanosperma* and *K. elatior*, having neglected rhizome structure which I believe to be an extremely valuable diagnostic character. Very similar in gross morphology is *K. polyphylla* which is described below.

14. ***K. polyphylla*** Willd. ex Kunth, Enum. Pl. 2, 134 (1837); Boeck., in *Linnaea* 35: 409 (1868); C. B. Clarke in Durand and Schinz, Conspect. Fl. Afr. 5: 531 (1895), and in Thiselton-Dyer, Flora Trop. Afr. 8: 276 (1902) and in Kew Bull. Add. Ser. 8: 93 (1908) (name only); Chermeson, Catal. Pl. Madag. 8 (1931). Type: India, Herb. Willd 1441 (B. holo.—seen in photograph).

Kyllinga macrantha Boeck. in *Linnaea* 35: 420 (1868) p.p.

Kyllinga aromatica Ridl. in Trans. Linn. Soc. 2, ser. 2 Bot.: 146 (1884).

Kyllinga planiceps C. B. Clarke in Durand and Schinz, Conspect. Fl. Afr. 5: 531 (1895).

Kyllinga elatior C. B. Clarke in Durand and Schinz, l.c.: 528 pro parte (Angolan material), Rendle in Catal. Afr. Pl. Welw. 2: 104 (1899).

K. erecta Schum. var. *polyphylla* (Willd. ex Kunth) Hooper, Kew Bull. 26: 580 (1972), Hooper in Hepper, Fl. W. Trop. Afr. ed 2. 3, 2: 307 (1972).

Cyperus aromaticus (Ridl.) Mattf. et Kükenth. in Engler, Pflanzenr. 4, 20: 581 (1836).

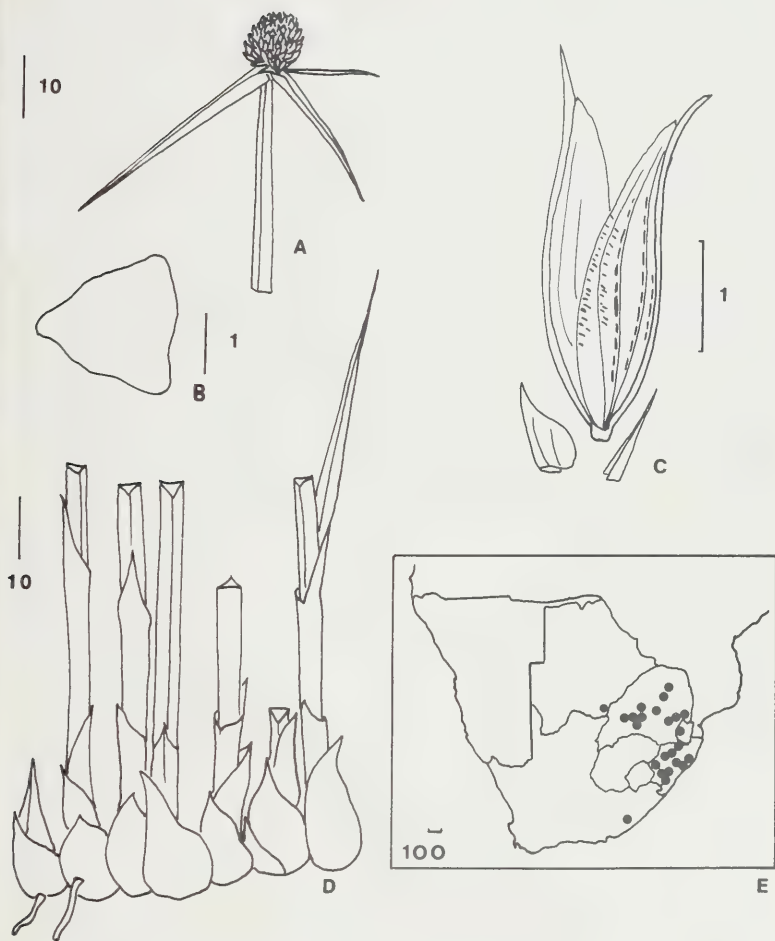


FIG. 16

Morphology and distribution of *K. melanosperma*. A. Inflorescence subtended by short stiff bracts. B. Cross-sectional outline of the culm. C. Whole spikelet with rust streaks on flanks of fertile glumes. D. Congested contiguous stem-bases forming rhizome. E. Distribution of the species in southern Africa. Figure scales in millimetres: map scale in kilometres.

Roots thick, fibrous. *Rhizome* horizontal, stout (5–8 mm diam.), congested (internodes 2–4 mm), covered with red to black acuminate, imbricate scales with transparent membranous margins. *Stem-bases* bulbous-thickened, covered with red-brown cuspidate scales with membranous margins. *Culms* 300–640 mm tall, triangular, glabrous, congested, usually in uniseriate row. *Leaves* 2–4, far apart, less than $\frac{1}{2}$ length of culms, lower leaves reduced to sheaths, upper sheaths shortly laminate; sheath long, membranous, red-brown, blade flaccid, 2–4 mm wide, flat, margins on keel scabrid. *Bracts* 3–8, usually approximately equal in length, 130–210 mm spreading. *Inflorescence* of 3 spikes confluent into subglobose head, greenish-white, central spike 5–10 mm in diam., lateral much smaller. *Spikelets* numerous, ovate-lanceolate in outline, 3–4 mm long. *Fertile glumes* 2, unequal, plus third hyaline reduced upper glume, lowest 9-nerved, subtending bisexual floret, middle 5-nerved, subtending male floret, upper empty; glume keels green, wingless, sparsely spinulose, excurrent into slender acuminate recurved mucro (0.20–0.57 mm long). *Stamens* 3, anthers linear, connective produced and red. *Style* exceeded in length by style branches. *Nut* 1 small (approximately 1 mm long), obovoid, apiculate, golden to red-brown, later black.

NATAL—2931 (Stanger): Durban, roadside Windsor Avenue, Windsor Park Golf Course (-CC), Getliffe 28, 164, 282 (NU).

In May, 1963, a population of *Kyllinga* plants was found growing in light sandy soil on the roadside in Windsor Avenue, Durban. This was a well established but very localised population. Plants were characterised by the 3–6 “flaccid” bracts aggregated at the apex of each culm and subtending a very small inflorescence usually composed of three closely associated, greenish-white, globose heads. Subsequent identification showed these plants to be *K. polyphylla* Willd. ex Kunth. Confirmation was obtained by comparison of dried specimens with sheets in the British Museum.

Mr. J. Lewis who carried out these comparisons, and to whom grateful thanks are due, commented as follows, “The British Museum has many sheets of this species bearing determinate labels *K. polyphylla* in Clarke’s hand. These match Getliffe specimens very well.”

Included amongst the sheets with which the Getliffe specimens were compared was the type of *K. planiceps* C.B. Clarke, a later synonym of *K. polyphylla*.

This single record of *K. polyphylla* is intriguing and difficult to explain, and despite extensive collection along the Natal coast, no other populations have been found. This then is the southern-most record of this tropical species.

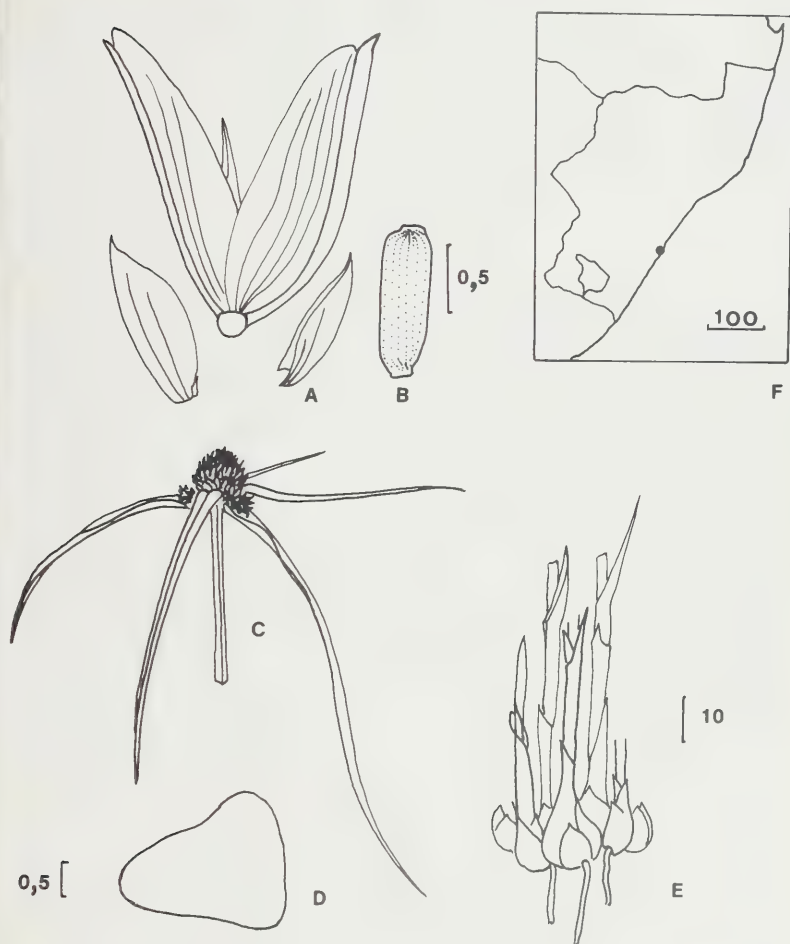


FIG. 17
Morphology and distribution of *K. polyphylla*. A. Whole spikelet with nutlet removed (B). C. Inflorescence of major terminal head and two minor lateral heads, with subtending bracts well developed. D. Cross-sectional outline of culm. E. Congested stem-bases constituting the rhizome. F. Known distribution in South Africa restricted to date to a single record in Natal. Figure scales in millimetres: map scale in kilometres.

Hooper (1972) related *K. polyphylla* to a variety of *K. erecta* which decision is not retained here as *K. erecta* is very different in size and orientation of bracts, rhizome morphology, and inflorescence form. It is also very distinct from *K. elatior* but could be confused with *K. melanosperma* unless attention was drawn to the long bracts and multiple head. The rhizome of *K. polyphylla* in Durban is always obliquely ascending but this may be due to the adjustment due to topdressing on the grassy verge.

GENERAL

The genus *Kyllinga* includes grassland forms such as *K. odorata*, *K. alba* and *K. alata* which appear to be able to tolerate full sun and drier soil than the majority of the genus which exhibits a preference for damp habitats. *K. melanosperma* is intolerant of shading by surrounding vegetation but *K. elatior* thrives in shady situations. In an experiment testing the range of tolerance of soil moisture changes, *K. nemoralis* proved to be extremely adaptable though in natural populations it was always found in damp sandy soils.

The centre of distribution of the genus is undoubtedly tropical Africa. Migration southwards appears to have taken place along two flanks. The western path leads to a distribution in tropical Africa extending into South West Africa as is the case in *K. albiceps* and *K. welwitschii*. The eastern path is more extensive. Some species penetrate as far as Natal and are restricted to coastal areas (*K. polyphylla* and *K. elatior*). Others are more extensive and occur throughout the Transvaal, Orange Free State and Natal (*K. melanosperma*, *K. odorata*, *K. pauciflora*, *K. erecta*, *K. intricata*). Only *K. alba* has been recorded from tropical Africa and from across Botswana to the east coast and south through the northern Cape, Orange Free State and Natal. *K. alata*, in contrast, is limited to southern Africa and has been recorded in the south western Cape.

ACKNOWLEDGEMENTS

The author is indebted to the University of Natal for use of the facilities of the Bews Botanical Laboratories. The generous help and guidance of Professor Kathleen Gordon-Gray, Mr. John Lewis (British Museum of Natural History), Miss Sheila Hooper (Kew) and Mr. E. A. Robinson is gratefully acknowledged, as is the unfailing enthusiasm and support of her family. The cooperation of the directors of herbaria who provided specimens including type material is acknowledged with thanks:

Botanischer Garten und Botanisches Museum, Berlin-Dahlem;
British Museum of Natural History;
Botanical Museum and Herbarium, Copenhagen;
Moss Herbarium, University of Witwatersrand;

Herbarium, Royal Botanic Gardens, Kew;
National Herbarium of Victoria, Melbourne;
Natal Herbarium, Durban;
University of Natal Herbarium;
Fielding-Druce Herbarium, Oxford;
Muséum National d'Histoire Naturelle, Paris;
Botanical Research Institute, Pretoria;
Swedish Museum of Natural History, Stockholm;
Bergius Foundation, Stockholm.

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**TYLECODON KRITZINGERI: A NEW TYLECODON (CRASSULACEAE)
FROM THE NORTH WESTERN CAPE**

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ABSTRACT

A new species of *Tylecodon* (Crassulaceae) is described from the north western Cape.

UITTREKSEL

**TYLECODON KRITZINGERI: 'N NUWE TYLECODON-SOORT VANAF
NOORDWES-KAAP**

'n Nuwe *Tylecodon*-soort (Crassulaceae) vanaf Noordwes-Kaap word beskryf.

Key words: *Tylecodon*, sp. nov., Crassulaceae, north western Cape.

Tylecodon kritzingeri E. J. van Jaarsveld, sp. nov.; a *Tylecodon suffultus* Bruyns ex Toelken differt, multo maiore plante, erecta ad 1 000 mm alta.

Plantae perennes, ramis scandentibus gracilibus, 3–4 mm in diametro, radicibus tuberosis saepe ramosis. *Folia* linear-elliptica. *Inflorescentia* thyrsus, 1–3 monochasiis, quoque 1–3 floribus. *Sepala* triangulari-lanceolata 5 mm longa, acuta, glabra, succulenta, viridia. *Corolla* infundibularis; tubo 20–25 mm longo glabro; lobi 8–10 mm longi, lanceolati, acuti, glabri, sanguinei; stamina 12 mm longa, filamentis rectis, pilis patentibus praecipue in partibus quibusconnatis tubo petalorum. *Carpella* ovariis gracilibus gradatim constructis in stylos erectos stigmatibus terminalibus.

Typus: Cape Province—2817 (Tatasberg): Lower N W slope of Oemsberg (-AC), *Van Jaarsveld and Kritzinger* 6278 (NBG, holotypus).

Plants perennial, glabrous in all parts (except the filaments) single-stemmed or rarely branched, scrambling or scandent into bushes up to 1 m. *Roots* tuberous and branched, up to 10 mm in diameter. *Stems* slender, light green, 3–4 mm in diameter and succulent at first, erect and later spreading, becoming grey with dark striations, woody and snapping when bent. *Leaves* alternate and spirally arranged, linear to linear-elliptic and acute at apex,

Accepted for publication 30th March, 1983.

erectly spreading and often becoming recoiled acting as tendrils, grooved on the adaxial surface, abaxial surface convex, becoming deciduous towards summer. *Inflorescence* a spreading thyrse up to 200 mm in diameter with 1–3 monochasia each bearing 1–3 spreading flowers. *Calyx* glabrous, lobes triangular-lanceolate, and acute, 5 mm long and 2 mm broad. *Corolla* pale green, 20 mm long, 4 mm wide at the base and gradually expanding to 7 mm, lobes 8–10 mm long, lanceolate and acute at apex, at first erect and becoming erectly spreading; inner surface maroon to dark maroon, lower half with green striations. Filaments light green, 12 mm long, fused to corolla in lower half and sparingly pilose respectively, squamae yellowish-green, quadrangular and emarginate, 1 mm \times 1 mm. *Carpels* with slender ovaries gradually tapering to erect styles. Stigmas terminal.

Flowering period: January.

DISTRIBUTION AND HABITAT

This species occurs in the upper Gannakouriep river valley on the north west slopes of the Oemsberg, Western Mountain Karoo (Acocks Veld type no. 28), where it is scandent among xerophytic shrubs. The plants are locally common. Rainfall occurs mainly in winter and ranges from 150–200 mm per annum.

DISCUSSION

Tylecodon kritzingeri van Jaarsveld is a very distinct species and shares, with *Tylecodon suffultus* Bruyns ex Toelken, the habit of being the only scrambling members of the genus. However, the two are not closely allied and are quite distinct.

Tylecodon kritzingeri van Jaarsveld is a much larger plant with large funnel-shaped glabrous maroon flowers which bear erectly spreading lobes. (*Tylecodon suffultus* Bruyns ex Toelken is as yet only recorded from the Vanrhynsdorp district and is a much smaller plant with thicker branches and pink flowers; the corolla also possesses glandular hairs on the outside). The linear leaves of *T. kritzingeri* which often recoil and act as tendrils are unique in the genus. This species is the fastest growing in the genus. Plants that were grown under controlled glasshouse conditions at Kirstenbosch produced stems 700 mm tall within one growing season. The open corolla persists for approximately 8 days.

Tylecodon kritzingeri was first discovered on the 21st September 1981 by the author on a collecting expedition together with Mr. Kobus Kritzinger of the Cape Department of Nature Conservation. I have pleasure in naming this species after Mr. Kritzinger who has made a substantial contribution to nature conservation in Namaqualand and particularly in the Richtersveld.

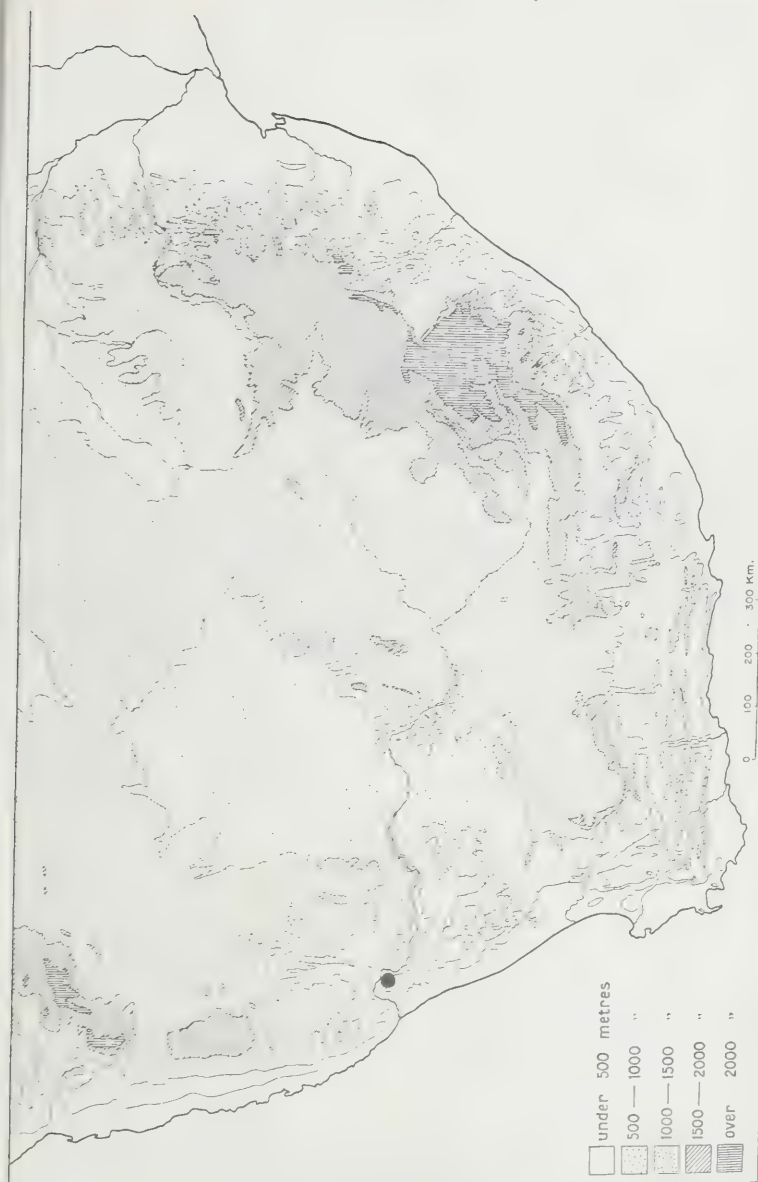


Fig. 1.
Distribution of *Tylecodon kritzingeri*.



FIG. 2. *Tylocodon kritzingeri* van Jaarsveld, sp. nov. 1. Inflorescence; 2. Corolla; 3. Calyx; 4. Roots; 5. Young shoot; 6. Fruit.

Mr. Kritzinger is at present Officer-in-charge of the Hester Malan Nature Reserve at Springbok and has collected many interesting records of plants in that area and has also taken the author to many inaccessible areas.

ACKNOWLEDGEMENTS

Mrs. E. Ward-Hilhorst is thanked for her beautiful illustration, and Mr. Norval Geldenhuys for checking the Latin diagnosis.

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BOOK REVIEWS

THE MONOCOTYLEDONS: A COMPARATIVE STUDY, by Rolf M. T. Dahlgren and H. Trevor Clifford, with pp. 378. London: Academic Press, 1982. ("Botanical Systematics": an occasional series of monographs, edited by V. H. Heywood). US\$ 98,00, £48,00. ISBN 0-12-200680-1.

The familial and ordinal classification of the flowering plants has always been a complex problem fraught with the difficult questions of homology, convergence and character significance. Nevertheless the search for better and more natural schemes continues. And with time more and increasingly diverse kinds of data have become available to be applied to the problems of classification. At the same time the difficulties of assembling, assimilating and interpreting the great quantities of data are compounded. Rolf Dahlgren and Trevor Clifford have produced in this book a remarkable effort at presenting much of the available data that can be brought to bear on systematic problems for the monocotyledons and synthesizing it into a coherent whole in the form of a revised scheme of classification for the monocots.

Data of systematic value have been brought together from innumerable sources and condensed into a form that the reader can digest. The larger part of this impressive work is a survey of the "distribution of selected characters and their states". Some 100 characters are dealt with, most of them accompanied by appropriate illustrations, and their occurrence is plotted on bubble diagrams of those orders of the monocots which the authors recognize in their classification scheme, presented in an earlier chapter. In these diagrams, introduced and used by Dahlgren in a series of publications on plant phylogeny and classification, the bubbles represent the orders of monocots arranged spatially to indicate in a simple way, broad evolutionary relationships.

A wide variety of characters are dealt with including traditional organ morphology (e.g. ovary position, ptyxis, venation patterns); as well as anatomy (e.g. laticifers, stomata structure and origin, vessel shape); embryology (e.g. pollen morphology, tapetum types, ovule structure, placentation); chemistry (e.g. steroid saponons, cyanogenic compounds, flavonols and flavones); and a selection of less unorthodox features such as fine structure (sieve tube plastid bodies); and host specificity (e.g. plant lice, various fungi).

A fundamental paradox, common to systematic studies in general, is that a system of classification is developed by the evaluation and synthesis of data, and then the classification is used to present and discuss this data. Although this may seem self serving, it is the most efficient way to present and deal with systematic situations. To be fair, the authors present a thorough historic review of monocot classification before developing their own. One of the outstanding features of the Dahlgren-Clifford classification is their treatment of the order "Liliales" in its current broad sense, and it is this aspect which will have most impact on southern African systematists. This is broken down into several orders, the fundamental division being the separation of Asparagales from Liliales as well as the recognition of Burmanniales, Orchidales and isolated small orders like Haemodiales, Velloziales, Philodrales, and Bromeliales. Within Asparagales, united especially by the frequent presence of a black, phytomelan seed crust, are several families not often accorded this status including some important in Africa like Asparagaceae; Dracaenaceae; Amaryllidaceae (here not including Alliaceae); Tecophilaeaceae; Hyacinthaceae (Scilloideae); and Aspho-

delaceae (Anthericoideae). Apart from a now relatively small North Temperate Liliaceae (14 genera), Liliales comprises Iridaceae (the largest), Colchicaceae (Wurmbeaioideae) and some non-African families, importantly Melanthiaceae, also largely North Temperate.

Many of the families accorded recognition here have most often been included in a large, very diverse and heterogeneous "Liliaceae" in the past, sharing little except a generalized petaloid monocot ground plan. The system presented here is one of several developed in the last few years and it will take time for a consensus to evolve on which is the most useful, practical and correct (if any one system fulfils all these requirements). The Dahlgren-Clifford system seems to be for the most part, a natural scheme and the most acceptable one so far developed and it is certainly the most fully documented classification for the monocots yet presented. Despite this, it will take many years before the system or a modification of it will be accepted. Such is the conservative and traditional bias in plant systematics.

An interesting section near the end deals with the vexing question of the relationship of the monocots to the dicotyledons. There are several current hypotheses dealing with the problem, all reviewed by Dahlgren and Clifford, who favour the idea that Dioscoreales are close to the basic monocot stock and that this group has its closest affinities with Aristolochiales. This in turn is close to the basal magnolioid lines that comprise the most primitive of the living dicots. This runs counter to the more widely favoured theory that the aquatic monocots, Alismatales sens. lat. are the most primitive monocots and that they are allied to the dicots through the Nymphaeales.

This book is a model of its kind in plant systematics and no botanical library can afford to be without it. It will be a valuable teaching aid, a useful reference for senior students as well as a fine research resource for systematists.

PETER GOLDBLATT

PLANT CARBOHYDRATES I: INTRACELLULAR CARBOHYDRATES, edited by F. A. Loewus and W. Tanner, with pp. xxii + 918 and 103 figures. Berlin, Heidelberg, New York: Springer-Verlag, 1982. Cloth, approx. US \$132.40. ISBN 3-540-11060-7.

This 1 840 g work represents volume 13A of the New Series of the well known and much appreciated "Encyclopedia of Plant Physiology". Together with *Plant Carbohydrates II*, it replaces the single volume of the original "Encyclopedia of Plant Physiology" which in 1958, adequately summarized the state of our knowledge about plant carbohydrates at that time.

This volume provides a comprehensive assessment of our current knowledge of the carbohydrates which usually do not occur outside the plasmalemma of living plant cells. For convenience, all organisms except animals and bacteria are regarded as plants and the treatise deals with the carbohydrates of fungi and algae in addition to those occurring in mosses, ferns and seed plants.

In contrast to what some might have expected, the emphasis throughout the book is on the physiological activity and metabolic involvement of the various carbohydrates rather than on their chemistry—as indeed befits a volume of an "Encyclopedia of Plant Physiology".

The 21 chapters which have been written by 62 well-known experts, are arranged in three sections. The first deals with the occurrence, metabolism and functions of the monosaccharides and oligosaccharides and related compounds. Special treatment

is given to sucrose and related oligosaccharides, as well as to the uronic acids, amino sugars, branched-chain sugars, sugar alcohols, cyclitols and heterosides (glycosides).

The second section deals with the occurrence, metabolism and function of those macromolecular carbohydrates which occur intracellularly, i.e. starch and other reserve polysaccharides, glycoproteins, glycolipids and sterol glycosides. Because of the importance of glycoproteins as lectins and as constituents of plasmamembranes, two chapters are devoted to this important class of compounds.

In the third (final) section five chapters are devoted to purely physiological aspects of carbohydrates: the translocation of sugars; the secretion of nectar; the storage of sugars in higher plants; the storage of starch; and the control by external and internal factors over the mobilization of reserve carbohydrates in higher plants.

The recommendations of the International Union of Pure and Applied Chemistry (IUPAC) regarding carbohydrate nomenclature, the rules of the International Union of Biochemistry (IUB) on oligosaccharides and polysaccharides and the recommendations of the IUPAC-IUB Commission on Biochemical Nomenclature were adhered to throughout.

This monumental work will no doubt become a standard reference work on plant carbohydrates for several years. It is clearly written and well illustrated. The many references at the end of each chapter are especially useful because the full titles of the papers and the lengths of the papers cited are provided in all cases. Apart from the usual subject index, an author index and a species index are also provided.

N. GROBBELAAR

PLANT CARBOHYDRATES II: EXTRACELLULAR CARBOHYDRATES, edited by W. Tanner and F. A. Loewus, with pp. xxii + 769 and 124 figures. Berlin, Heidelberg, New York: Springer-Verlag, 1981. Cloth, approx. US \$124.80. ISBN 3-540-11007-0.

This book represents volume 13B of the New Series of the authoritative "Encyclopedia of Plant Physiology" which has become a standard reference work on plant physiology. It deals with those carbohydrates and related compounds which are secreted by the protoplasm of plant cells and therefore usually occur outside the plasmalemma of such cells.

The carbohydrate components of the cell walls of fungi, algae and seed plants are dealt with in considerable detail. This is necessitated by the relatively recent discovery of the importance of carbohydrates in cell-cell surface interactions and recognition systems. Thus host-parasite and pollen-pistil interactions as well as symbiosis and the mating reaction in fungi are but some of the complex but fascinating physiological phenomena in which extracellular plant carbohydrates play key roles.

The book contains 26 chapters which have been written by 38 recognised experts in their respective fields. The chapters are grouped into five sections and the first, which deals with the cell walls of higher plants, contains no less than 11 chapters. They cover the constitution of the cell wall polysaccharides; the biophysical as well as the biochemical ultrastructure of the cell wall; the assembly of polysaccharide fibrils; the biosynthesis and metabolism of cellulose and noncellulosic cell wall polysaccharides; the glycoproteins and enzymes of the cell wall; the role of lipid-linked saccharides in the biosynthesis of complex carbohydrates; the biosynthesis of lignin, cutin, suberin and associated waxes; and finally the effect of hormones on cell wall extension.

Section two is devoted to the cell walls of algae and fungi—their composition, biosynthesis, cytology and degrading enzymes (autolysins)—eight chapters. The three chapters of section three all deal with secretion—especially as it occurs in fungi, the root cap of seed plants and in cell wall formation during cell division.

Sections four and five are probably the most topical. They deal with cell wall surface phenomena including lectin-carbohydrate interactions (2 chapters each). The involvement of carbohydrates in pollination and plant-pathogen interactions is discussed in section four. In the last section the physiological role of lectins in slime moulds and higher plants and in symbiotic plant-microbe interactions are discussed.

The presentation of the material, although encyclopedic, is excellent. It reads easily and is quite lucid and well illustrated. The references at the end of each chapter provide the full title and length of each publication. Apart from the subject index, an author index is also provided. A species index is, however, not included.

Because this volume deals with the more novel aspects of plant carbohydrate physiology, it is bound to become outdated sooner than Volume I. It is nevertheless a must for each University Botany Department and plant physiological research establishment and will no doubt be used as a standard reference work for several years to come.

N. GROBBELAAR

GROWTH AND DIFFERENTIATION IN PLANTS, by P. F. Wareing and I. D. J. Phillips, with pp. xi + 343. Oxford, New York, Toronto, Sydney, Paris, Frankfurt: Pergamon Press, 1981. US \$20 (F), \$40 (H). ISBN (F) 0-08-0263-510.

The third edition of Wareing's and Phillips' plant physiology textbook shows few differences from the second. The title has been shortened, some references added, the chapters organized into four sections, and each section preceded by a brief introduction. The chapter sequence, however, has been maintained. The heading of the last chapter has been changed from "The Control of Development" to "Gene Expression and Cell Determination in Development" and in the process the treatment of polarity moved to the first chapter "The Plant Cell in Development". New information added to this chapter includes that on the cell cycle and secondary wall formation.

The third edition has undergone a 25% increase in surface size without a corresponding increase in information, unfortunately making it a less wieldy book than its predecessor. The micrographs, generally, have been poorly reproduced (examples: Fig. 1.10, p. 12; Fig. 2.3, p. 24); some are clearer than the corresponding ones in the 2nd edition, but others are poorer by comparison (example: Fig. 2.5 B—designated b on the photograph—p. 25). Some graphic reprintings, compared with the original publications, have lost definition (examples: Fig. 9.1, p. 218; Fig. 11.1, p. 261); many line drawings and chemical configurations lack boldness (examples: Fig. 2.18, p. 38; Fig. 4.3, p. 79) and on some the lettering and symbols are too small and faint (example: Fig. 5.31, p. 140). There is, furthermore, much wasted space (some examples: pp. 32, 103, 116, 130, 166); space which could for example have been utilized to increase magnification of photographs, graphs and line drawings. As compared with an American or German botanical textbook I would have to judge the general design and layout as inferior.

Despite the overall inexcellence of the book's production, there is much to commend it. Dealing only with growth and development, it is not a general plant physiol-

Book Reviews

ogy text, but one that should be able to treat this complex discipline with authority. This, as is to be expected from Aberystwyth, certainly is the case in respect of the two central sections covering internal and environmental controls of development. The chapter on growth movements, in particular, has been expanded and greatly improved. The book is extremely readable, as up-to-date as one can expect a book of this nature to be (although I found no reference to Skoog's *Plant Growth Substances*, 1979), and displays a fresh perspective by relating phenomena under discussion to the experiments used in their investigations. It is a good teaching text.

To soften the comments made above about the illustrations: a reviewer in *Nature* (1982) pointed out the transformation which the flowering test-tube *Primula* underwent on the 3rd edition's cover page. The artist certainly has made it represent plant growth and development much more colourfully than was the case with its predecessor on the cover of the 2nd.

CHRIS H. BORNMAN

EXPERIMENTS IN PLANT TISSUE CULTURE, by J. H. Dodds and L. W. Roberts, with xiii + 178. Cambridge, London, New York, New Rochelle, Melbourne, Sydney: Cambridge University Press, 1982. £7.50. ISBN 0-521-23477-8 (hard cover); 0-521-29965-9 (paperback).

Although the number of books on plant tissue culture has increased dramatically over the past decade, few have dealt explicitly with methodology. One of the first was R. A. de Fossard's excellent, inexpensive and comprehensive *Tissue Culture for Plant Propagators* (The University of New England Printery, Armidale, Australia, 1976), and another the expensive, far less comprehensive *Plant Tissue Culture: A Laboratory Manual** by Reinert and Yeoman (Springer-Verlag, 1982). Now there has appeared (1982) a book that is packed with information and one that takes an approach which is different compared with the firstmentioned two.

The book under review comprises 14 chapters and is furnished with author and subject indexes, as well as lists of terms and commercial sources of supplies. Chapter 1 gives an interesting account of the history of plant tissue culture up to the present day. Chapters 2 and 3 treat the problems of aseptic techniques and culture media, respectively. Chapters 4 to 13 involve experiments that demonstrate the use of plant organ, tissue, cell and protoplast cultures as research tools. The final chapter is on a much neglected aspect of plant tissue culture, namely quantitation of procedures.

A useful feature of the book is the organization of each chapter. It begins with a brief historical background, the development of the problem, and a statement of purpose; then comes a list of materials required, a description of the procedure and results, and a number of questions for discussion; and finally, there follows an appendix with additional experiments and techniques, and a list of selected references.

It is obvious that the authors (JHD—a young, gifted and progressive plant biologist and LWR—well-known and respected for his book *Cytodifferentiation in Plants. Xylogenesis as a Model System*: Cambridge University Press, 1976) with this book will reach an audience that includes researchers from a variety of botanical disciplines, in addition to the undergraduate and advanced level high school students for whom it was intended. It goes further than being merely a laboratory textbook; it is also a useful source to most of the major studies that have high-lighted the development of plant tissue culture.

*Reviewed on page 317 of this issue.

Some errors, not all typographical (*Haplopappus gracilis* instead of *gracilis* in the index), have crept into the book. Examples: The generic name of tomato is spelt *Lycopersicum*, instead of *Lycopersicon*, throughout the book (also in the reference to Padmanabhan, p. 87). Sugar beet, *Beta vulgaris* is said (p. 124) to have a tuber, instead of a fleshy hypocotyl-root. The major shortcoming of the book is to be found in chapter 10 on the isolation, purification and culture of protoplasts. Reference could have been made here to the eminently more elegant techniques of J. F. Shepard and colleagues. Also, the dismissal of plant regeneration from protoplasts with a single short paragraph will certainly convey the false impression that it is but a few easy steps, when in fact it is very problematical indeed. Further, it surely is also Widholm (1972) and not only Larkin (1976) who deserves credit for assessment of viability using fluorescein diacetate.

Experiments in Plant Tissue Culture is a well-produced and highly informative textbook and one that is destined to be widely used.

CHRIS H. BORNMAN

PLANT PHYSIOLOGY, by I. P. Ting, with pp. ix + 642. Reading (Massachusetts), Menlo Park (California), London, Amsterdam, Don Mills (Ontario), Sydney: Addison-Wesley Publishing Company, 1982. US \$27.95. ISBN 0 201 07406 0.

Yet another relatively high-priced plant physiology text! What novel features might it offer? This question is not easily answered.

Much attention has been devoted to design. The subject matter of the 21 chapters has been divided variously over five parts. Each part's title is announced separately on a page in enormous headlines, below which there are what is referred to as "chapter opening photographs", one photograph for each chapter that follows. Part II, with six chapters, has six slim chapter opening photographs squeezed alongside each other. Each photograph, but now magnified 3×, reappears again with the introduction to the chapter. Following the page that announces the part, is a one or two page "prologue" which serves as a summarized introduction of the chapters comprising the part. The part is concluded by a "prospectus", a page or two that briefly reviews hypotheses, indicates the current state of research, and speculates briefly on future trends. The chapter opening photographs in reality have little if any bearing on the chapters, and are obviously intended to attract and hold the reader's attention, as are the bold black lines that run across the pages underlining chapter sub-headings. These features, unfortunately, detract from rather than add to the quality of the book.

The five parts are:

- (1) *Structure and function of cells and tissues*. This is an elementary introduction of plant cell (and tissue) structure and function which follows a prologue in which the author expresses the view that the concept of "structure-function is somewhat dangerous because it tends to lead to teleological interpretation".

It is understandable that liberal use was made of light and electron micrographs supplied by colleagues from institutions on the same campus (UC Riverside). However, a number of the photographs by no means represent the best illustrative material available (example: Fig. 1.11, vacuole-extruding protoplasts). The information on plant classification could better have been omitted. The author refers to the groups, divisions, orders and classes listed in Tab. 1.2 as species.

- (2) *Biophysical processes: exchanges with the physical environment*, (3) *Biochemical constituents of plants* and (4) *Metabolic processes of plants*. These three

parts form the bulk and heart of the book, making up for lack of depth by the breadth of their coverage.

- (5) *Growth and development: integrative processes*. Like part 1, this final section is elementary. It can at best be regarded as a quick, simplified scan of a discipline which the author (in the prospectus) regards as the most complex of plant physiology.

In particular, growth movements, the concepts of morphogenesis, differentiation and determination, and the plant hormones and growth regulators have been accorded shallow treatment.

It is difficult to judge to whom the book is addressed. If it is the undergraduate, it would seem that an introductory text such as *Biology of Plants* (Raven, Evert and Curtis: Worth) would be a superior choice, for in addition to physiology it also embraces the other disciplines of botany. If it is the graduate, there are more meticulous (*Lehrbuch der Pflanzenphysiologie*—Mohr and Schopfer: Springer), comprehensive (*Plant Physiology*—Salisbury and Ross: Wadsworth), scholarly (*Plant Physiology*—Thomas, Ranson and Richardson: Longman) and readable (*Plant Physiology*—Bidwell: MacMillan) textbooks available.

CHRIS H. BORNMAN

PLANT CELL AND TISSUE CULTURE: A LABORATORY MANUAL, by J. Reinert and M. M. Yeoman, with pp. 83. Berlin, Heidelberg, New York: Springer-Verlag, 1982. US \$22. ISBN 3 540 11316 9.

As indicated in the title, this book is a laboratory manual. It is aimed at students and others who are inexperienced in the techniques of plant tissue culture. The authors state clearly that there was no pretence of sophistication and that the experiments can be carried out with a minimum of facilities.

Altogether 17 experiments have been selected, from the simple establishment of callus to the more complex isolation and culture of leaf protoplasts, and arranged in six groups. The first set (Part II) of four deal with excision and explantation of tissues and the initiation of cultures, that is cell division and growth. Still dealing with cell division and growth, Part III includes two bioassay experiments for kinetin. Part IV covers morphogenesis and its four experiments illustrate plant regeneration *in vitro* via somatic embryogenesis from cell cultures and immature microgametophytes, from callus tissues, as well as from pseudobulbs. In Part V there are two experiments on the isolation, culture and fusion of protoplasts, and two in Part VI on secondary product synthesis. The last part (VII) includes three experiments on embryo and organ culture.

Obviously, scores of additional experiments covering a wider range of agronomic, ornamental, floral and vegetable plants could have been included; or, alternatively, one or two experiments demonstrating epigenesis (habituation, for example) or mutational changes might have added some zest and challenge to the objectives. However, since the authors made their intent quite clear in their introductory remarks, one should be grateful that a few plants other than the two classic, over-worked models of carrot and tobacco also feature in this volume's contents.

The experiments are presented clearly and concisely and are all relatively easy to carry out. However, the methods described for the isolation of mesophyll protoplasts are no longer used by anyone seriously interested in protoplast isolation, culture and plant regeneration, as they involve some time-consuming operations as well as sedimentation of the protoplasts by centrifugation. Missing, too, is information on the

use of stains and other methods to ascertain not only the viability of the protoplasts, but also the presence of subprotoplasts (cytoplasts, vacuoplasts, microplast) so that plating densities can be compensated for.

The layout uses an interesting approach even though it is reminiscent of that found in some modern cookbooks. The items required for an experiment are diagrammatically depicted in a box titled: "Items for the sterile transfer room". The items themselves are numbered, the numbers corresponding to the same listed under Materials and Equipment. So, for example, if a scalpel is listed sixth, it is found boxed in below and identified with the number 6. However, in succeeding experiments this item may have the number 5 or 7 or 11, and so forth. It would in my opinion have been better to present the layout in the transfer room only once, with all the items for all experiments boxed-in and numbered. The number would then have served the purpose also of permanent identification and the space of 18 boxes (ca. 2 500 cm²) would have been conserved. As it is, 16 of the book's 83 pages are virtually blank, making it, at US \$0.33 per page, a very expensive book indeed. Compare this with the average price of US \$0.11 per page of technical books in the natural sciences reviewed in *Science* (79: 47, 1983) for the year 1982. As far as being aimed at the inexperienced student, it can be reasonably predicted that this manual is destined for the copying machine.

(The book suffered the unfortunate fate of being recalled by the publisher, after it was discovered that the Index was incorrect.)

CHRIS H. BORNMAN

SALINE AND SODIC SOILS, by E. Bresler, B. L. McNeal and D. L. Carter, with pp. x + 236 and 78 figures. Berlin, Heidelberg, New York: Springer-Verlag, 1982. Cloth DM 98, approx. US \$43.60. ISBN 3-540-11120-4.

This book is another in the Springer-Verlag "Advanced Series in Agricultural Sciences", and conforms to the general format and quality of the series. It is well written with very few errors, and is usefully illustrated.

The book is in three approximately equal parts: 1. Diagnosis and Properties; 2. Transportation and Distribution of Salts; 3. Management.

Diagnosis and Properties deals with the sources of salts, some water quality and soil solution parameters, surface phenomena of salt-affected soils, salt dissolution and precipitation and the diagnosis of salinity properties. In general this section is comprehensive and well written, though more attention could have been given to the origins of sodic soils. A sample of saline and sodic soil forming minerals are mentioned but, for example, the sodic soils in granite areas where the granite contains albite (common in south-central Africa) are not included. The theoretical treatment of the exchange equilibria and other aspects of deposition, etc., is detailed and well illustrated.

The section on transportation and distribution of salts is comprehensive but will be difficult to follow for the average biologist who is not very numerate. The sixty pages of Section 2.3 (Modelling of Salt Flow Phenomena) are mostly beyond the needs and comprehension of botanists.

The final 45 pages on Management are interesting and of practical value, and written in a simple, easily understood style. Tables 15-18, which detail the relative productivities and salinity thresholds of a number of crop types, from sensitive to tolerant, under a range of increasing soil salinities, is a particularly useful reference. So, too, are the final sections on reclamation and specialized management practices.

I doubt that the book will become part of the average botanist's personal library, but I strongly recommend its inclusion in all general libraries. Although the examples are mostly American, the general principles apply universally and it will be an important reference and text for research workers in soil science, crop production and general plant/soil relationships.

B. H. WALKER

EXPERIMENTAL EMBRYOLOGY OF VASCULAR PLANTS, edited by B. M. Johri, with pp. 273 and 81 figures. Berlin, Heidelberg, New York: Springer-Verlag, 1982. DM 98, approx. US \$43.60. ISBN 3-540-10334-1.

During the past decade a large number of books have been published which dealt with the general field of tissue culture. In view of this, it is only natural to question whether the publication of the current volume was necessary? In view of the rapid advances which have been made in the field of experimental botany this book is entirely justified, more so, as it is intended as a brief and concise account of some of the more recent developments in this rapidly changing field. The book is aimed towards the undergraduate and postgraduate student. As such it was emphasized by the editor that no exhaustive literature reviews have been included. This does not detract from the various chapters which in the reviewer's view contain more than sufficient literature to stimulate the curiosity of young prospective students.

The book consists of a general introduction and nine other chapters which cover a wide spectrum of topics. They include: experimental embryology of pteridophytes; experimental embryology of gymnosperms; flower culture; anther culture; ovary, ovule, and nucellus culture; pollen-pistil interaction and control of fertilization; endosperm culture; embryo culture and protoplast culture. All chapters give a brief review of the literature and then concentrate on some of the more recent discoveries and developments in the respective fields under discussion. Throughout a fairly critical approach has been adopted. Attempts were made to give impetus to future research by the identification of some of the problems which have been encountered in some fields of study.

The volume is neatly presented and the printing and figures are of a high quality. The book is reasonably priced and should be on the shelves of all teaching and research institutions.

J. VAN STADEN

HISTORICAL PLANT GEOGRAPHY, by Philip Stott, with pp. 151. London: George Allen & Unwin, 1981. R16.60. ISBN 0-04-580010-3; 0-04-580011-1 (pbk.)

The saying that a geographer has to be a scientific Jack-of-all-trades finds its confirmation in this concise book of 151 pages. Mr. Stott has brought a complicated branch of botanical science in all its ramifications to the student as well as to the interested layman. The book starts with a discussion on the suitable selection of study areas whether limited to species or genus levels or a continent-wide family level (Chapter 1). In Chapter 2 the importance of correct taxonomy, based on reliable annotated collections and well-prepared herbarium material, is duly stressed. The discussion of the term "type" on page 21, however, could have been clearer. The last section on

advanced methods should perhaps have been transferred to Chapter 3 which dwells on the methods applied in the production of plant maps and the selection of the best suitable projections. Although great importance is laid on a show of the selected projection and of a bar scale, some of the map examples should also have shown at least one latitude and longitude, especially on maps of remote regions, as for instance figure 3.6 on page 40.

Chapter 4 deals with patterns of distribution based on the floristic elements of the various distribution types in the world. The use of the word territory on page 47 is somewhat misleading as in zoology the term denotes an area which is defended by an animal against others of the same species. Chapter 5 investigates the reasons behind the various distribution patterns. The author delves into the multiplicity of a number of ecological phenomena to arrive at conclusions on the origin of distributions and their boundaries, based essentially on the autecology of the species in question. In this connection he quotes Holland's "An evolutionary biography of the genus *Aloe*" (J. Biogeog. 5, 213-226) as an attempt to find the centre of origin for the genus. In principle this may be sound enough, although I feel that the taxonomy of this genus is in need of revision, particularly that of the sessile and shortstemmed maculate group where systematic sampling would almost certainly reveal clinal phenomena with consequent reduction in the number of species, especially in the epicentre of distribution in the Transvaal.

Well represented is the section dealing with the disruptions of distribution by the drift of the continents in the wake of plate tectonics and sea floor spreading. A few more examples of species affected by these geological events would have been welcome. The section on climatic changes in the past is a little too brief. However, the train of thought is continued in Chapter 6 where the full importance of macro- and microfossils, especially that of pollen analysis, is emphasised.

Chapters 7 and 8 on disjunct distribution patterns and the endemism problem are very clear and well represented, although some of the evidence, for instance plate 7.1 dealing with the distribution history of the Proteaceae which is linked to plate tectonic events, could already have been brought in in Chapter 5. Later the problems of vicariousness and speciation under isolation are discussed. Island and high mountain populations are explained. In Chapter 9 the author dwells on the future influence of cyto- and chemotaxonomy on plant geographical methods. Although these disciplines are becoming increasingly in the mode, it should be emphasised here that their techniques are to be considered more as an aid to taxonomy and systematics rather than the end product. If too vigorously applied, their final effect on taxonomical terms such as species, subspecies and varieties by the creation of a multitude of hybrids might be rather disconcerting and impractical if taxonomical keys designed for botanists in the field are based thereon.

In conclusion, I would state that this is a very readable book couched in easily understandable scientific language and well illustrated by drawings, diagrams and tables. The cover, more suitable for a history of taxonomy, is somewhat unattractive. The layout is good, the price reasonable. All interested in this fascinating subject, whether students or laymen, should try to read this book

N. H. G. JACOBSEN

NEW PERSPECTIVES IN WOOD ANATOMY, edited by Pieter Baas, with pp. vi + 252. The Hague: Martinus Nijhoff Publishers BV, 1982. Dfl. 130, approx. US \$54.00. ISBN 90-247-2526-7.

For over 50 years the International Association of Wood Anatomists has cham-

pioned the scientific study of wood structure. The society and its many distinguished members have made important contributions to investigations of wood anatomy. Especially noteworthy among the achievements are the standardization of wood terminology, the publication of scientific articles on wood structure and function, the encouragement for developing a worldwide network of repositories for vouchered wood samples and wood microslides, and the establishment of a spirit for free exchange of specimens and knowledge around the world, both in basic and applied areas. Over most of its history, publications of IAWA have covered many subjects, but especially many systematic topics and regional surveys of wood, so on their 50th anniversary one might have expected a book summarizing these achievements.

Instead, IAWA once again demonstrated leadership by producing *New Perspectives in Wood Anatomy* (P. Baas, ed.), a commemorative volume on the latest techniques and interesting avenues of research for wood analysis. The nine chapters are extended versions of invited papers presented at the 1981 anniversary gathering at the International Botanical Congress in Sydney, Australia by leading authorities on wood study.

The book begins with a chapter on the early history of IAWA as reconstructed by W. L. Stern from publications, private correspondence, and personal sleuthing. Not only is this an excellent and lucid account of the actual events and controversies, but also here one gains a real flavour for the personalities of S. J. Record, L. Chalk, and B. J. Rendle, the founders of IAWA and the principal pioneers charting its early course. Such an account will be treasured by present and future anatomists, who cannot obtain this valuable historical perspective in our modern educational setting.

Much wood research has asked the question, "Why are woods similar or different?" Naturally, workers have searched diligently for the answers, cautiously hoping that similarities might help solve taxonomic and phylogenetic problems. In Chapter two, P. Baas briefly narrates this search, beginning with the earliest anatomists, and the author presents a new perspective on Antoni van Leeuwenhoek, who has not been given adequate credit for his descriptions and illustrations of wood.

As investigators studied more woods, they became cautiously optimistic that wood structure would help to classify taxa, but eventually they had to adopt the conclusion that wood anatomy is no more dependable than many other features—good systematics must carefully evaluate wood features along with all other comparative evidence. Baas mentions the Baileyan (phylogenetic) trends in wood evolution only briefly because this is pre-empted by several excellent reviews; however, the author does emphasize the important but now well-known caveat that many trends are reversible under certain conditions, a fact of which I. W. Bailey himself was aware and encouraged in the 1960's. Most of the chapter is devoted to "ecological wood anatomy," resurrected by S. Carlquist in the 1960's. Here investigators attempt to understand why woods change, in relation to what ecological factors. Unfortunately, Baas, like others, presents no concrete answers, only narratives based on broad studies using the correlation approach. Data can be assembled to suggest this trend or that one, but, in fact, the answers will come when anatomists analyse how plant phenology, whole plant physiology, and growth habit, not merely habitat, are linked to wood structure. This chapter could have been more lucidly written.

In the next chapter, M. H. Zimmermann discusses one aspect of the relationships between wood structure and physiology, hydraulic conductance. Much of this information has been published before, but this is a useful review. However, the author has also made an important contribution by emphasizing the importance of studying vessel length, whereas wood descriptions based on sections and macerations always emphasize vessel-element length.

Chapter four is a fascinating review by the skilful electron microscopists B. G. Butterfield and B. A. Meylan of the very recent research on formation of perforation

plates in vessels. Anatomists will appreciate the detailed discussions on hydrolysis of cell wall components and still marvel at the mystery that hydrolysis degrades some parts of the cell wall more than others. Even in this last part of the 20th century, we have not yet elucidated the final stages in vessel pore formation!

The two following chapters are excellent accounts of the origin of the vascular tissues. In his characteristic style, P. R. Larson deliberately and cautiously traces the origin of procambium and eventual development of cambium. Although the author probably did not have to reiterate the early stages of procambium in embryos, he clearly and expertly showed how the transition from procambium to cambium is a continuum. Specialists on plant structure have recognized this for a long time, but the point must be thrust forward because beginning students are still accustomed to thinking that primary and secondary growth are discrete and definable. Next G. P. Berlyn reviews the most recent information on developmental and morphogenetic events in the cambial zone. So much needs to be learned about the impact of morphogenetic factors on the cambial initials and derivatives, and Berlyn's chapter gives leads for future research.

Every wood anatomist is well aware that wood samples can vary tremendously, depending on the place and climate of collection but also upon differences among individuals in a single population or position within a single plant. These sources of variability are discussed by J. Burley with the goal to provide wood technologists with knowledge for screening specimens in breeding programs. The techniques described should help workers identify genetically superior woods and save much time in trial-and-error research.

In a similar vein, a chapter by Burley and R. B. Miller shows how statistics and computers are becoming indispensable in wood studies. In the future, much data-capturing on wood dimensions, including the storage and retrieval of measurements, the development of dichotomous keys, and the identification of unknown specimens, will be accomplished by computers.

Perhaps the most difficult chapter to digest is by J. D. Boyd, which attempts to model the effects of physical stresses on layers of microfibrils in wood fibre cell walls. Unfortunately, most wood anatomists are not trained in biophysics, so the results will have a narrow audience. Nevertheless, the subject is especially important to wood technologists and wood breeders. Other models are needed to describe how physical stresses affect the wood characteristics and growth habits of living trees, so that we may eventually explain the numerous wood fibre designs in the secondary xylem of dicotyledons.

Overall this volume is attractive and pleasant to read. Its subject is universally applicable to those doing research on wood. Especially laudable is the long list of literature following each chapter. Unfortunately, the high price of this thin book will probably limit its distribution to libraries and to those researchers working directly in areas that are covered.

ARTHUR C. GIBSON



WILHELM JAN LÜTJEHARMS (1907-1983)

On 3rd February 1983 South African Botany lost a true scholar and philosopher in the passing of Wilhelm Jan Lütjeharms, Emeritus Professor of Botany and Microbiology at the University of Cape Town. During his academic career he had the distinction of occupying three individual chairs at South African Universities and his death will be particularly mourned by the many students, both English- and Afrikaans-speaking, who have benefited so richly from his wise and inspiring teaching at the Universities of the Orange Free State and Cape Town.

Accepted for publication 16th May, 1983.

Wilhelm Lütjeharms was born in Alkmaar, that little town some 35 km north of Amsterdam so famous for its cheeses, on 24 January 1907. It was there that he received his school education and also his early interest in matters biological, inculcated during walks through the countryside with his grandfather, and by his collection of that remarkable series of scientifically accurate nature study albums produced by Jac. P. Thysse and the Verkade Company of Holland, which influenced so greatly an entire generation of Dutch youth.

He entered Amsterdam University in 1924 to study for his Candidaat's examinations in Natural Philosophy, majoring in Botany and Zoology. He graduated in 1927 and such was the standard of his academic achievements that, after a spell of lecturing at Amsterdam University, he was successful in gaining a post in the prestigious Rijksherbarium, Leiden; this in spite of his youth (Wilhelm was always the youngest student in his classes) and the great depression of that time which precluded most of his classmates from finding scientific employment. While working in the Rijksherbarium as Curator of the Mycological Collections, he was able to study further for his Doctorandus examinations under Professors Westerdijk (Plant Pathology), Weevers (Plant Physiology) and Stomps (General Botany), all leaders in their respective disciplines at the time. He then enrolled at the University of Leiden for his doctorate of philosophy under the direction of the famous scientific historian Professor Baas Beeking. Even at this stage he had become interested in South African Botany through his contact with the South African Collections of the Rijksherbarium and had originally intended to write his thesis on the life and works of Persoon, that famous South African Mycologist regarded as the father of systematic mycology. In this aspiration he was, however, frustrated as a senior German colleague had "adopted" Persoon for his own research (never published) and Wilhelm therefore switched his doctoral project to a mammoth study of the history of Mycology during the 18th century. His brilliant thesis on this topic was published in the *Mededeelingen van de Ned. Mycologische Vereeniging*, deel 23, in 1936 under the title "Zur Geschichte der Mykologie DAS XVIII Jahrhundert". During this period he married Anne-Marie Bloemendaal, a young lady from his home town whom he had known from school days and who was to prove such a staunch support to him throughout his life both as wife and academic colleague.

As a result of his doctoral thesis, Wilhelm was awarded a Fellowship of the Royal Netherlands Academy of Science (Buitenzorg Fonds) for a six months study of the mycology of Java (the present Indonesia). Here he spent a happy and productive period with his wife, and was also able to carry out a botanical survey of the island of Enggano off the west coast of Sumatra for the Dutch Forestry Department and the Buitenzorg and Leiden

Herbaria. He came home with a whetted appetite for more exciting floras than that of his own native Netherlands. Thus, when the chair of Botany at the University College of the Orange Free State was advertised in 1938, he followed up his early interest in the flora of this country and applied for the post which, to his delight, he was successful in obtaining.

He arrived at a very different University to the U.O.F.S. we know today. Money was scarce and very little apparatus of any sort existed in the department he had inherited from Professor Potts. Being somewhat disappointed by the scarcity of higher fungi in the Bloemfontein area he turned his attention to the soil micro-flora and so established the science of soil microbiology at the University. Improvisation was the order of the day. Autoclaves were derived from pressure cookers; culture racks were made from paraffin tins cut in half and filled with sand. When he applied for a laboratory assistant the University Council informed him that such a luxury was quite out of the question owing to shortness of funds, so his wife, Anne-Marie, became his unpaid assistant responsible for the subculturing of the fungal collection he was rapidly building up. Her remuneration was two cups of coffee a day. Gradually progress was made and, building on his earlier work in the Rijksherbarium, he was soon to establish himself as an international authority in the field of soil microbiology.

During his professorship at Bloemfontein he travelled widely, thanks to the award of Carnegie, Rockefeller, C.S.I.R and Deutsche Forschungsgemeinschaft Fellowships, visiting England, Denmark, Sweden, Germany, Belgium, France, Canada and the United States to work with colleagues and to present papers at international congresses. He became the first professor to give lectures in Microbiology at any South African University and can therefore truly be called one of the founding fathers of this scientific discipline in the country. He was appointed to the Steering Committee for Microbiological Chemistry at the C.S.I.R., an office he held for many years (1961-1975), and served at a critical time in the country's scientific development on a number of influential official committees including the Medical-Biology Committee of the Atomic Energy Board, the Committee on International and Scientific Co-operation and the Advisory Committee for Biological Sciences of the C.S.I.R. At his own university he was appointed Head of the Institute of Soil Biology which he had been so strongly influential in founding.

In 1962 Wilhelm Lütjeharms came to the Cape to occupy the Harry Bolus Chair of Botany at the University of Cape Town, the oldest botanical Chair in the country. At this time the University was striving to establish a microbiological component in its scientific curriculum and to Wilhelm fell the task of co-ordinating these activities in addition to his already onerous duties as Head of the Botany Department. The success of his endeavours

was witnessed in 1970 by the establishment within the University of a fully-fledged Department of Microbiology and his own appointment as first Professor of Microbiology, a post he held with distinction until his retirement in 1972.

Not only was Wilhelm a dedicated scientist but he had also a strong interest in the philosophy and history of Science. His papers on these subjects, in the writing of which he was ably assisted by his wife, Anne-Marie, a scholar in her own right, are highly regarded by the scientific community. The pursuit of this interest resulted in his building up one of the finest private scientific libraries in the country which now houses well over 5 000 volumes and 14 000 reprints covering a broad spectrum of scientific and philosophical topics. He commenced this enormously valuable collection while still a student when he had the leisure to attend the frequent academic book sales which took place in Amsterdam and Leiden, and augmented it on each of his return trips to Europe. The cataloguing of his reprint collection he always carried out from 04h30–07h00 on Sunday mornings. (He invariably rose at 04h30 in summer and, as a concession to the longer nights, 05h00 in winter).

His leadership in scientific and philosophical circles has been recognised by the award of a Fellowship of the Royal Society of South Africa in 1951 and by his election to the Presidency of this august body in 1966. He also served the scientific community as Council member or member of numerous scientific bodies including the American and South African Associations for the Advancement of Science, Die S.A. Akademie vir Wetenskap en Kuns, the S.A. Association of Botanists, the British and American Mycological Societies and the Royal Netherlands Botanical Society. His interest in cultural affairs was very strong and he was tremendously keen on promoting cultural ties between Europe and South Africa. This he was able to do in Bloemfontein as President of the Alliance Française and through his committee work for the Algemene Nederlands Verbond; in Cape Town he was President of the Verbond Nederlands-Suid Afrika for a number of years.

In spite of his scientific achievement, Wilhelm will probably be best remembered by his students for the excellence of his teaching. As one of the country's best-read scientists Wilhelm had an extraordinary wealth and depth of knowledge on which to base his lectures. This knowledge he communicated to his students with a clarity and humour which, together with his gentleness of manner and compassion for those less gifted than himself, made him a deeply loved and respected lecturer and councillor.

In the passing of Wilhelm Lütjeharms the scientific community of South Africa has lost a gifted scholar, researcher and philosopher who has served

it well. He is survived by his widow, Anne-Marie, his son Dr. Johann Lütjeharms, already a prominent scientist like his father, his daughter, Mrs. Marijke Haarhoff, and his grandchildren.

O. A. M. LEWIS

TWO NEW SPECIES OF *PSORALEA* (FABACEAE) IN SOUTH AFRICA

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ABSTRACT

Two new species of *Psoralea* L. are described. One of these, *P. implexa* C.H. Stirton, is recorded from the Mountain Fynbos vegetation type on Du Toit's Peak, near Worcester; and the second, *P. trullata* C.H. Stirton, from the southern Cape Mountains.

UITTREKSEL

TWEE NUWE *PSORALEA* (FABACEAE) SOORTE IN SUID-AFRIKA

Twee nuwe *Psoralea*-soorte word beskryf. Die een, *P. implexa* C.H. Stirton is in Bergfynbos plantegroei op Du Toitspiek naby Worcester en die tweede, *P. trullata* C.H. Stirton, is op die suidelike Kaapse berge gevind.

Key words: *Psoralea*, sp. nov., Fabaceae, southern Cape, south western Cape.

INTRODUCTION

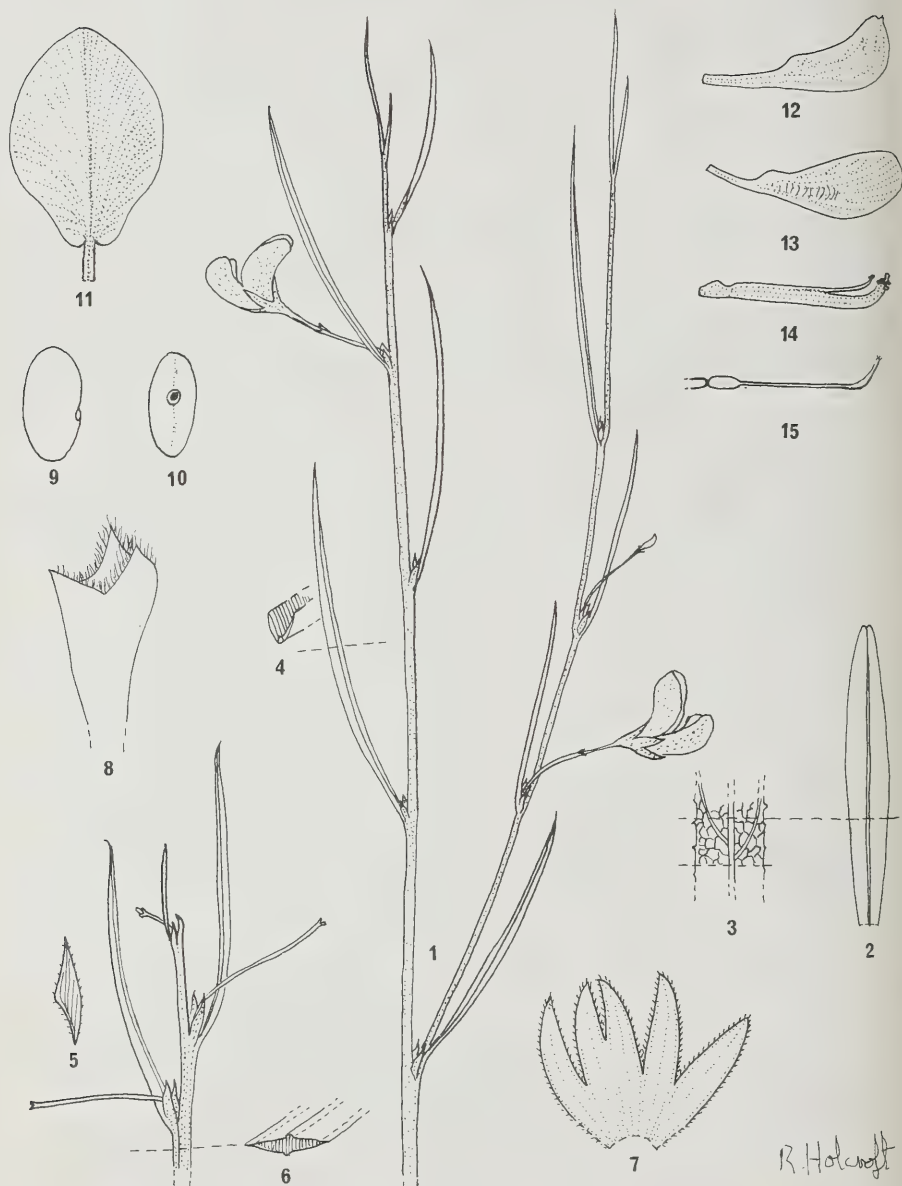
In 1930 Miss H. M. L. Forbes published her revision of 49 species of *Psoralea* L. in southern Africa. Since that time many new areas have been opened up to exploration and it is therefore not surprising that some new species have been discovered.

This paper is a tribute to Elsie Esterhuysen whose collections of *Psoraleoid* legumes in South Africa are of critical importance to our understanding of *Psoralea* and *Otholobium* C.H. Stirton. The two new species described here are rare and unusual representatives of the genus *Psoralea*.

Psoralea implexa C.H. Stirton, sp. nov.; *P. trullatae* C.H. Stirton affinis sed habitu graminoso, caulibus complanatis, floribus solitariis latericiis vel salmoneis, vexillolate elliptico et cupula brevite trifida differt.

Planta perennis rhizomata acervis implexos formans. *Caulēs* complanate, angulati glabrescentes. *Folia* unifoliolata. *Foliola* linearioblonga vel falcata, apice basique acuminatis. *Flores* solitarii axillares 12 mm longi laterici vel

Accepted for publication 12th April, 1983.



salmonei. *Cupula* breviter trifida. *Calyx* accrescens. *Vexillum* late ellipticum. *Carina* alas superans apice rotundata.

Type: CAPE—3319 (Worcester): Delabat Ravine, NE ridge of Du Toit's Peak (-CA), 7/2/1975, *Esterhuysen* 33765 (NBG, holotype; BOL, NBG, PRE, isotypes).

Rhizomatous multi-stemmed perennial growing in tangled heaps, with some trailing branches up to 1.7 m long. *Stems* flattened, angled, glabrescent. *Leaves* unifoliolate. *Stipules* 3–6 mm long, 1–3 mm wide, fused at base, adnate to base of petiole, falcate; blade glabrous, glandular, margins papillose or hairy. *Petioles* 1 mm long, glabrous. *Leaflets* 35–60 mm long, 2–3 mm wide, linear-oblong to falcate, basal leaves shorter and up to 4 mm wide; glabrous, glandular; apex acuminate, base acuminate. *Inflorescence* reduced to a single flower, axillary, forming near the ends of lateral branches. *Flowers* 12 mm long, brick-red to salmon. *Cupulum* shortly trifid. *Calyx* 8 mm long; teeth equal, 8 mm long, 1.8–2.0 mm wide; vexillar lobes fused for three-quarters their length, incurving; tube 3 mm deep; lobes glabrous outside, finely ciliate on margins of the teeth and on inner face of teeth; accrescent in fruit. *Standard* 12 mm long, 8 mm wide, broadly elliptic, weakly auriculate, appendages absent; glabrous; apex convex, slightly beaked; claw 3 mm long. *Wing petals* 10 mm long, 3 mm wide at widest point, 1.5 mm wide below weak auricle; claw 3.5–4.0 mm long; sculpturing upper basal comprised of 8–12 irregular, reclined lamellae. *Keel blades* 9.0–9.5 mm long, 3.5 mm wide, rounded at apex and beaked below, shorter than the wing petals; claw 4 mm long. *Androecium* 9 mm long, 2 mm wide at base, split; vexillar stamen lightly fused for the middle part of its length. *Pistil* 9 mm long; ovary 1.5 mm long, glabrous except for a few glandular hairs on the sides; gynophore present, 1 mm long; height of curvature 2.5 mm; style glabrous, somewhat thickened before the point of flexure; stigma capitate, finely penicillate. *Fruit* 6 mm long, 4 mm wide, papery, reticulate. *Seed* brown black, 5 mm long, 3 mm wide (Fig. 1).

This species is so distinctive that I have no hesitation in describing it as new.

SPECIMENS EXAMINED

Type only, as above

FIG. 1.

Psoralea implexa (*Esterhuysen* 33765): 1. Flowering branch; 2. Leaflet; 3. Undersurface of leaflet; 4. Transverse section of leaflet; 5. Stipules; 6. Transverse section of stem; 7. Calyx; 8. Cupulum; 9. Lateral view of seed; 10. Hilar view of seed; 11. Standard; 12. Keel blade; 13. Wing petal. 14. Androecium. 15. Pistil. (1, 4, $\times 1$; 2, $\times 2$; 2, 3, 7, 9–15, $\times 3$; 5, 6, $\times 5$; 8, $\times 8$)

DISTRIBUTION AND BIOLOGY

Psoralea implexa is a rare mountain endemic collected for the first and only time just six years ago (Fig. 2). It was found growing by Miss Elsie Esterhuysen at 650 m on steep open rocky stony slopes of kloofs with western and eastern aspects. Flowering takes place in early February. Nothing is known about its biology.

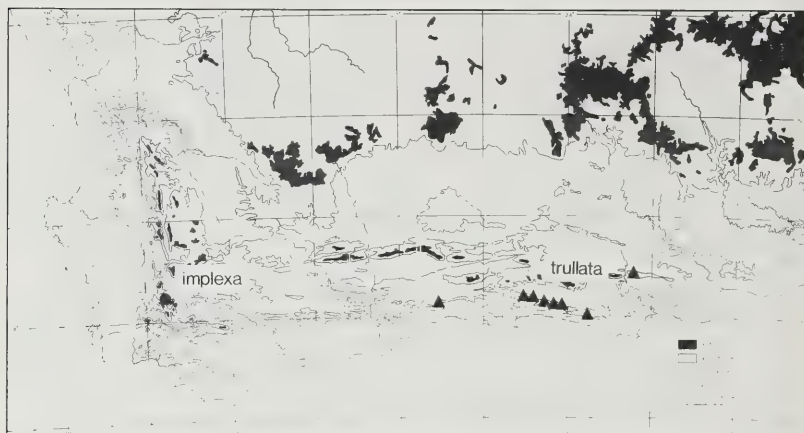


FIG. 2.

Known distribution of *Psoralea implexa* (●) and *P. trullata* (▲) in South Africa.

DIAGNOSTIC FEATURES

Grass-like habit, flattened stems, solitary brick-red to salmon-coloured flowers, broadly elliptic standard and shortly trifid cupulum.

Psoralea trullata C.H.Stirton, sp. nov.; *P. restioides* Eckl. & Zeyhr. et *P. implexae* C.H.Stirton atque *P. glaucinae* Harv. affinis sed vexillo trulliforme, cupulae dentibus longioribus angustioribus, carina dentibusque calycis alabastro valde attenuatis.

Suffrutex *implexa* multicaulis usque 300 mm alta. *Caules* usque 2 mm longi glabri manifeste glandulosi. *Folia* trifoliolata inferiores unifoliolata basales plani latique superne gradatim trifoliolata conduplicata angustioribus, foliola linearia vel linearioblonga basi cuneata apice acuminata. *Flores* solitarii axillares 10–12 mm longi purpureo-coerulei. *Cupula* 3–5 mm longa, tubo 1,5 mm longo, trifida, duobus dentibus interioribus 4,0–4,5 mm longis anguste triangularibus, dente exteriori rotundato quam interiores 4–5-plo bre-

viori. *Calyx* accrescens. *Vexillum* latissime triangulare vel trullatum. *Carina* manifeste attenuata alas prominente auriculatas valde superans.

Type: CAPE—without precise locality: Blaauboschbaai, *Fourcade* 2827 (PRE, holotype; STE, isotype).

Tangled multi-stemmed suffrutex, up to 300 mm tall. *Stems* as much as 2 m long, glabrous, ribbed, prominently glandular. *Leaves* trifoliolate, occasionally unifoliolate below. *Stipules* 5–7(10) mm long, adnate to the petiole, tightly clasping the stem, fused for three-quarters their length; teeth narrowly triangular, 2.0–4.5 mm long. *Petioles* 5–12 mm long. *Leaflets* 10–16 mm long, 0.5–2.0 mm wide; basal leaves flat and broader becoming conduplicate and narrower towards the apical regions; glabrous, linear to linear-oblong; base cuneate, apex acuminate; laterals equal to or somewhat shorter than the terminal leaflet. *Inflorescence* reduced to a single flower, axillary, occurring in the last 2–5 axils. *Flowers* 10–12 mm long, purplish-blue, subtended by two unequal bracts 2–3 mm long; pedicel 2–5 mm long. *Peduncle* 10–25 mm long; cupulum 3–5 mm long with 1.5 mm deep tube, trifid, inner pair of teeth 4.0–4.5 mm long, narrowly triangular, outer tooth rounded, 4–5 times shorter than the inner pair, 1.0–1.5 mm long. *Calyx* 12 mm long; upper four teeth equal, 8 mm long, keel tooth broader and 4 mm long, upcurving, vexillar lobes fused for two-thirds their length; tube 2.5–3.0 mm deep, ribbed; lobes glabrous inside and outside, ciliate along margins of the teeth, densely glandular, accrescent in fruit. *Standard* 13–14 mm long, 8 mm wide, very broadly triangular to trullate; claw 2.5 mm long; scarcely auriculate, appendages obscure, may be absent. *Wing petals* 14–15 mm long, 3 mm wide, claw 3 mm long; prominently auricled, thumb-like, 1.5 mm long. *Keel blades* 20–21 mm long, slender, narrowly beaked, exceeding the wing petals; claw 4 mm long. *Androecium* 6 mm long, vexillar stamen free. *Pistil* 6 mm long; ovary 2 mm long; gynophore present, 0.5 mm long; height of curvature 1.5–1.6 mm long; style glabrous, thickened at point of flexure; stigma capitate, penicillate. *Fruit* 5–6 mm long, 3 mm wide, black, paper-thin, broadly reticulate. *Seeds* 4 mm long, 2.5 mm wide, blackish-brown (Fig 3).

In the past this species has been referred to either *P. glaucina* Harv. or to *P. restioides* Eckl. & Zeyhr. It is easily separated from those species however by its prominent elongated buds, the trullate standard, and very distinctive keel.

SPECIMENS EXAMINED

CAPE—3322 (Oudtshoorn): Tolberg, top of Outeniqua Pass (-CD), 8/12/1962. *H. C. Taylor* 4469 (STE).



R. Holcroft

—3323 (Willowmore): de Hoek farm, Langkloofberge, 22/2/1945, *Fourcade* 6535 (BOL); Helpmekaar Peak (-DC), 28/1/1941, *Esterhuysen* 4604 (BOL); Formosa Peak, Tsitsikamma Mountains, 30/1/1941, *Esterhuysen* 4651 (BOL); Cradock Peak, Montagu Pass, 1/1940, *Stokoe s.n.* (SAM 54873); Camel Pile, Tsitsikamma Mountains (-CD), 12/1/1947, *Esterhuysen* 13573 (BOL); Tsitsikamma Mountains near Joubertina, 26/1/1950, *Esterhuysen* 16764 (BOL, PRE).

—3324 (Steytlerville): Witte Els Bosch Peak (-CD), 16/11/1941, *Esterhuysen* 6789 (BOL); Cockscomb Peak, Great Winterhoek Mountains (-DB), 3/3/1957, *Esterhuysen* 27144 (BOL).

Without precise locality: Blaauboschbaai, *Fourcade* 2827 (PRE, STE).

DISTRIBUTION AND BIOLOGY

Psoralea trullata is endemic to the southern Cape and is found growing on the Tsitsikamma, Langkloof, Outeniqua and Great Winterhoek Mountains (Fig. 2), between the altitudes of 1 100 and 1 600 m. Very little is known about the habitat preferred by this species except that it is associated with steep rocky slopes and ledges (*Esterhuysen* 27144), apparently on peaty soils overlying TMS rock (*Taylor* 4469). Flowering takes place between November and February.

DIAGNOSTIC FEATURES

Tangled herb; trullate standard; elongated flower bud; trifid unequally toothed cupulum; narrowly attenuated keel-blade exceeding the prominently auricled wing petals; accrescent calyx.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the assistance and facilities made available to him at the Botanical Research Institute, Pretoria and Stellenbosch, the Compton Herbarium and the Bolus Herbarium. The illustrations were drawn by Mrs. Rosemary Holcroft of the Botanical Research Institute, Pretoria and are gratefully acknowledged. Miss C. M. Wilmot-Dear kindly provided the Latin diagnoses.

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FIG. 3.

Psoralea trullata (*Fourcade* 2827): 1. Flowering branch; 2. Calyx in fruit; 3. Calyx; 4. Cupulum; 5. Bracts subtending each flower in a cupulum; 6. Bud; 7. Standard; 8. Keel blade; 9. Wing petal; 10. Pistil; 11. Androecium. (1, \times 1; 2, 3, 6, \times 3; 7–11, \times 4; 4, \times 5; 5, \times 8).

TWO NEW SPECIES OF *OTHOLOBIUM* (FABACEAE)

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ABSTRACT

Two new species of *Otholobium* Stirton are described. One of these, *O. rubicundum* C.H.Stirton, is recorded from the transition belt of Succulent Mountain Scrub and False Macchia on the Klein Swartberg Mountains; and the second, *O. pictum* C.H.Stirton, from the Baviaanskloof Mountains.

UITTREKSEL

TWEE NUWE *OTHOLOBIUM* (FABACEAE) SOORTE

Twee nuwe *Otholobium* Stirton-soorte word beskryf. Een van die soorte, *O. rubicundum* C.H.Stirton, word gevind in die oorgang strook van Sukkulente Bergstruikveld en Skyn-Fynbos op die Klein Swartberge en die tweede, *O. pictum* C.H.Stirton op die Baviaanskloofberge.

Key words: *Otholobium*, sp. nov., Fabaceae, southern Cape, eastern Cape.

Otholobium rubicundum C.H.Stirton, sp. nov.

Frutex parvus, effusus. *Foliola* trifoliolata. *Foliola* 15-25 mm longa, 4-6 mm lata, conduplicata, anguste ovovata, glabrescentia, valde recurvato-mucronata, basi cuneata; lateralibus breviora. *Inflorescentia* 3-6 flora, axillaris. *Flores* 9-10 mm longi, rosei. *Dentes calycis* aequales. *Vexillum* late ovatum, vix auriculatum, unguiculatum. *Alae* carina longiores.

Type: CAPE—3321 (Ladismith): Hoeko road, south base of Klein Swartberg (-AD), 10/1957, *Barker 1606* (NBG, holotype).

Small spreading shrublet. *Stems* slender, ridged, waxy, sparingly covered with glands and small appressed white hairs. *Flowering shoots* axillary, appressed pubescent with numerous elliptic raised pustules. *Leaves* trifoliolate. *Stipules* 2.5-3.5 mm long, 1.5-2.0 mm wide, triangular; papery, sparingly pubescent but covered with orange-coloured, sunken, rounded glands. *Petioles* < 1 mm long, hairy. *Leaflets* 15-25 mm long, 4-6 mm wide, conduplicate, glabrescent, glandular, narrowly obovate, base cuneate, apex strongly

Accepted for publication 12th April, 1983.

recurved mucronate; laterals shorter than terminal leaflet. *Inflorescence* axillary, condensed, comprising 1–2 sets of triplet flowers; each set subtended by a single 3 mm long, 1.5 mm wide, narrowly obovate, acute, hairy and glandular bract. *Flowers* 9–10 mm long, pink; pedicel 2 mm long. *Peduncle* 1–2 mm long. *Calyx* 7 mm long; teeth equal, margins densely ciliate, 4 mm long, upper four teeth 1.7 mm wide, keel tooth 3 mm wide, vexillar teeth slightly connate; lobes prominently glandular, glabrous inside and outside except for a few hairs along the ribs; tube 3 mm deep, ribbed. *Standard* 12 mm long, 8 mm wide, broadly ovate, scarcely auriculate, appendages absent; claw 4 mm long. *Wing petals* 10–11 mm long, 3 mm wide, auricle 1 mm high; sculpturing upper basal and left central comprised of 35–40 parallel lamellae. *Keel blades* 7 mm long, 3 mm wide, blade bulging; claw 3.5 mm long. *Androecium* 7 mm long; vexillar stamen fused to sheath for two-thirds its length. *Pistil* 5.5 mm long; ovary 1.5 mm long, glandular with few hairs, gynophore absent; height of curvature 1.5 mm long; style glabrous 0.5–0.6 mm thick at point of flexure; stigma minutely capitate, finely penicillate. *Fruit* and seed unknown.

Otholobium rubicundum is very rare, having been collected for the first time, as recently as 1957, by Miss W. F. Barker. This species has not been found since, despite a thorough search by the author in 1980.

SPECIMEN EXAMINED

Same as for type.

DISTRIBUTION AND BIOLOGY

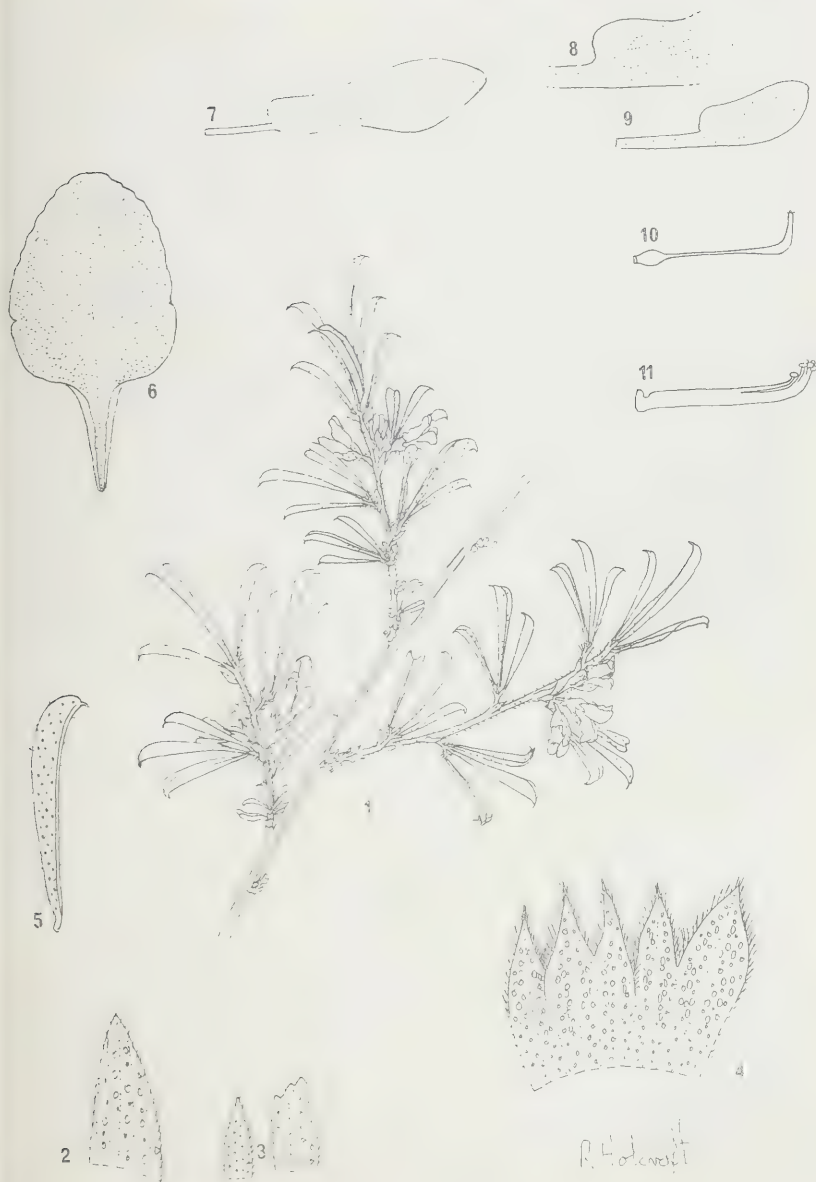
Otholobium rubicundum was found by Miss Barker at an altitude of about 650 m, apparently in the transition belt between False Macchia and Succulent Mountain Scrub vegetation types. Apart from the knowledge that flowering takes place during late October and early November little else is known about the biology of this rare and distinctive shrublet.

DIAGNOSTIC FEATURES

Small spreading shrublet; leaflets conduplicate, glandular; inflorescence 3–6-flowered, condensed; flowers pink, each triplet subtended by a narrowly obovate acute bract; standard broadly ovate.

FIG. 1.

Otholobium rubicundum (Barker 1606): 1. Flowering shoots; 2. Stipule; 3. Flower bracts; 4. Calyx opened out; 5. Leaf; 6. Standard; 7. Wing petal; 8. Base of keel; 9. Keel; 10. Pistil; 11. Androecium. (1, $\times 1$; 2–11, $\times 4$.)



Otholobium pictum C.H.Stirton, sp. nov.

Frutex erectus usque 2 m altus. *Rami* luteo-fusci. *Folia* trifoliolata. *Folia* 15–25 mm longa 2,5–3,0 mm lata plana, anguste obovata atque aliquantum falcata, prominente nigropunctata, recurvata, mucronata, basi cuneata, lateralia minoria. *Inflorescentia* 60–90-flora, dense spicata, late ovata vel oblonga. *Flores* 9–10 mm longa, albi. *Calycis dentes* inaequales lobus carinae ceteris lobis 2 mm longior. *Vexillum* late ellipticum, vix auriculatum, unguiculatum. *Alae* carina longiores.

Type: CAPE—3324 (Steytlerville): Baviaanskloof mountains, between Smitskraal and Wilgehof (-CB), 17/9/1973, *Oliver 4588* (STE, holotype; PRE, isotype).

Erect shrubs up to 2 m tall. *Stems* slender, glabrous, weakly ribbed, yellowish-brown. *Flowering shoots* clustered at the ends of the previous years shoots, densely appressed white pubescent between the angles, with elliptic pustules scattered along the upper edges. *Leaves* trifoliolate. *Stipules* 2,5–3,0 mm long, 0,5–0,8 mm wide, fused to the base of the petiole, shortly triangular, scarcely pubescent, densely encrusted with orange glands especially at the base. *Petioles* 1,5–2,0 mm long, gland-encrusted. *Leaflets* 15–25 mm long, 2,5–3,0 mm wide, flat, glabrescent, prominently nigro-punctate in dried specimens, narrowly obovate, somewhat falcate, base cuneate, apex recurved mucronate; laterals shorter and narrower than terminal leaflet. *Inflorescence* densely spicate, broadly-ovate becoming oblong, comprising from 20–30 sets of triplet flowers; each subtended by a single broadly ovate, pubescent glandular bract. *Flowers* 9–10 mm long, white; subsessile. *Peduncle* absent. *Calyx* 8 mm long; upper four teeth more or less equal, 6 mm long, 1 mm wide, keel tooth 8 mm long, 1 mm wide; vexillar teeth partially connate; lobes covered in small glands, densely black tomentose outside; tube 3,0–3,5 mm deep. *Standard* 9,0–9,5 mm long, 6,5 mm wide, broadly elliptic, emarginate, slightly auriculate, appendages absent; claw 2 mm long. *Wing petals* 9 mm long, 2,0–2,5 mm wide, longer than the keel, auriculate, claw 3,0–3,3 mm long; sculpturing upper basal, upper central and upper left distal comprised of 20–26 irregularly parallel lamellae. *Keel blades* 7 mm long, 2,5 mm wide, apex rounded; claw 3,5 mm long, purple blotch present on inner face of tip. *Androecium* 7 mm long; vexillar stamen 6,0–6,5 mm long, loosely fused to sheath for half its length. *Pistil* 6,5–7,0 mm long; ovary 2,5 mm long, pubescent; gynophore 0,5 mm long; style glabrous, 0,4 mm thick at point of flexure; stigma papillose, forward-sloping. *Fruits* and seed unknown.

Otholobium pictum was first collected in 1930. Since then it has been collected only twice. But considering the inaccessibility of the terrain in which



FIG. 2.

Otholobium pictum (Oliver 4588): 1. Flowering shoot; 2. Calyx with petals removed; 3. Calyx flattened out; 4. Leaf, surface view; 5. Tip of leaf; 6. Standard; 7. Stipule; 8. Keel; 9. Wing petal; 10. Androecium; 11. Pistil. (1, $\times \frac{3}{8}$; 4, \times ca. 1; 3, \times 3; 6, 8–11 \times 4; 7, \times 8)

this distinctive species occurs it is not surprising that the only collections made so far have been along the only two passable roads across the Ba-viaanskloof and Great Winterhoek Mountains. It is probably fairly common on the escarpment and with further collecting by mountaineers it should have its range broadened substantially. The discovery of this species stresses once again the poor state of collecting along the inland mountains east of Uitenhage and north of Stormsriver.

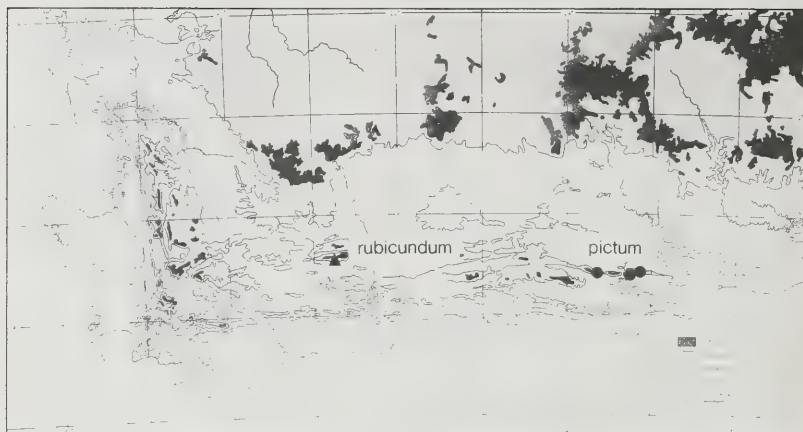


FIG. 3.

Known distribution of *Otholobium rubicundum* (▲) and *O. pictum* (●).

SPECIMENS EXAMINED

CAPE—3324 (Steytlerville): Baviaanskloof Mountains, between Smitskraal and Wilgehof (-CB). 17/9/1973, *Oliver 4588* (PRE, STE); Wintershoek Mountains (-DB), 15/9/1930, *Fries, Norlindh & Weimarck 1065* (PRE, STE); Mountain road north of Patensie, 12/7/1954, *Taylor 1285* (PRE, SAAS).

DISTRIBUTION AND BIOLOGY

Otholobium pictum, a distinctive endemic of the Baviaanskloof Mountains, remains little known and seldom collected. It is quite surprising that such a distinctive shrub should have been without a name for so long.

This species flowers during August and September. Nothing more is known about its biology.

DIAGNOSTIC FEATURES

Erect 2 m tall shrub; leaflets flat, nigro-punctate; inflorescence 60–90-flowered, densely spicate; flowers white, each triplet subtended by a broadly ovate bract; standard broadly elliptic.

ACKNOWLEDGEMENTS

I would like to thank Mr. E. G. H. Oliver (Stellenbosch) for his comments about *O. pictum*; Miss C. M. Wilmot-Dear for the Latin diagnoses; Mrs. R. Holcroft for kindly drawing the plates and Dr. B. de Winter, Director, Botanical Research Institute, for permission to publish them. Finally I would like to thank the Curators of the Compton, Kew, Saasveld, Stellenbosch (Government) and National Herbaria for the loan of their material.

**BOWIEA GARIEPENSIS: A NEW BOWIEA SPECIES (LILIACEAE)
FROM THE NORTH WESTERN CAPE**

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ABSTRACT

A new *Bowiea* species (Liliaceae) is described from the north western Cape (R.S.A.)

UITTREKSEL

BOWIEA GARIEPENSIS: 'N NUWE BOWIEA-SOORT VANAF NOORDWES-
KAAP

'n Nuwe *Bowiea*-soort (Liliaceae) vanaf Noordwes-Kaap (R.S.A.) word beskryf.

Key words: *Bowiea*, sp. nov., Liliaceae, north western Cape.

Bowiea gariensis E.J. van Jaarsveld, sp. nov.; differt ab *Bowiea volubilis* Harv. quia habet prostratos ad pendulos et glaucos caules, qui ferunt conspicuos et albos flores 25 mm diametris, stigmatibus 4,5 mm longis.

Type: Cape Province—2919 (Pofadder): Upper south slope of Groot Pellaberg (-AA), van Jaarsveld 6650 (NBG, holotype; PRE, isotype).

Geophyte, glabrous in all parts. **Roots** fleshy, white, up to 5 mm in diameter. **Bulb** globose, depressed, 60–140 mm in diameter, subterranean or somewhat exposed, the exposed part green, often forming 2–3 bulblets; tunics thick (up to 8 mm) and fleshy; outer tunics withered, grey and membranous, completely covering the bulb. **Leaves** appearing before the inflorescence, lanceolate, canaliculate up to 25 mm long and 10 mm wide, striate, withering shortly prior to flowering. **Stem** (inflorescence) annual, pendulous and scrambling, much-branched, basally flexuose, up to 1.2 m long, softly succulent, glaucous; branchlets subulate, 20–70 mm long, 2,5–5 mm in diameter; bracts lanceolate, spurred, 3–5 mm long, about 2 mm wide at the base; pedicels arched, 25–70 mm long. **Flowers** opening diurnally, relatively few, scented. **Perianth** 25 mm in diameter, divided to the base, segments

patent, oblong to lanceolate, 12 mm long, 3.5 mm broad with a medium green stripe, margins revolute towards the base; apex subacute, each perianth lasting approximately 8–10 days. *Stamens* suberect, about 5 mm long. *Ovary* broadly conical, 5 mm in diameter at the base, light green. *Style* terete with a 3-lobed stigma.

Flowering period: March to June.

DISTRIBUTION AND HABITAT

Bowiea gariensis occurs in Namaqualand Broken Veld (Acocks Veld type no. 33) in the lower Orange River valley in Namibia and South Africa, from Helskloof (Richtersveld) in the west to Pellaberg in the east.

The plants are procumbent and pendulous among rocks and occur mainly on south-facing slopes, being in shade for most of the day. The stems tend to sprawl, often cascading over the rocks. The plants are locally abundant. Rainfall is mainly in autumn and winter and ranges from 50–200 mm per annum.

DISCUSSION

Bowiea gariensis is a distinct species of the winter rainfall region of the north western Cape. The glaucous pendulous stems with the conspicuous white, larger corolla, and the spreading segments, clearly separate it from the only other member of the genus in South Africa, *Bowiea volubilis* Harv. The active growing season of *Bowiea gariensis* is from April to September, and the plant becomes deciduous towards the summer. In contrast, *Bowiea volubilis*, which occurs in the central and eastern parts of South Africa, grows during the summer months. The latter species has bright green branches and an inconspicuous green corolla with distinctly reflexed segments. In addition, the bulb of *Bowiea gariensis* is covered with grey membranous sheaths which are lacking in *Bowiea volubilis*.

SPECIMENS EXAMINED

CAPE—2817 (Vioolsdrif): Northern base of Little Helskloof (—CB), *Wisura* 1462 (NBG 1035/70).
—2819 (Ariamsvlei): Pelladrift (—CC), *Dinter* 5795 (SAM); Warmbad (—BD), *Range* 696 (SAM).

ACKNOWLEDGEMENTS

Miss Deirdré Snijman is thanked for help and for editing the manuscript; Mrs. Ellaphie Ward-Hilhorst for her illustration, and Mr. Norval Geldenhuys for the preparation of the Latin diagnosis.



FIG. 1.
Bowiea gariensis van Jaarsveld, sp. nov.

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THE AFRICAN GENUS *TRITONIA* KER-GAWLER: PART 2. SECTIONS *SUBCALLOSAE* AND *MONTBRETIA*

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ABSTRACT

The remaining two sections of the genus *Tritonia*, namely *Subcallosae* sect. nov., with five species, and *Montbretia* (DC.) Pax with 14 species, are dealt with, concluding the revision of the genus, with a total of 28 accepted species. These two sections are widespread, mainly in the summer rainfall regions of South Africa, and also in several African countries south of the equator.

Illustrated descriptions of the species, their range and synonymy, as well as keys, are provided. In section *Subcallosae* two new varieties are described and three species are reduced to subspecific rank. Four new species are described in section *Montbretia*, namely *T. delpierrei*, *T. drakensbergensis*, *T. karooica* and *T. marlothii*. A list is given of ca. 50 species excluded from the genus, and a few insufficiently known species are recorded. There is also a note with newly acquired data on *T. tugwelliae* that was treated in Part 1.

UITTREKSEL

Die oorblywende twee seksies van die genus *Tritonia*, naamlik *Subcallosae* sect. nov., met vyf spesies, en *Montbretia* (DC.) Pax met 14 spesies, word behandel, waardeur die hersiening van die genus afgesluit word, met 'n totaal van 28 aanvaarde spesies. Die twee seksies kom wydverspreid voor, hoofsaaklik in die somerreënvalstreke van Suid-Afrika, en ook in sekere Afrikalande suid van die ewenaar.

Geïllustreerde beskrywings van die spesies, hul sinonimie en verspreiding, word gegee en sleutels word verskaf. In seksie *Subcallosae* word twee nuwe variëteite beskryf en drie spesies word tot subspesifiese rang verlaag. Vier nuwe spesies word vir seksie *Montbretia* beskryf, nl. *T. delpierrei*, *T. drakensbergensis*, *T. karooica* en *T. marlothii*. 'n Lys word gegee van die ongeveer 50 uitgesluite spesies, en enkele onvolledig bekende spesies is opgetel. Daar is ook 'n nota met nuwe feite oor *T. tugwelliae* wat reeds in Deel 1 behandel is.

Key words: *Tritonia*, sect. *Subcallosae*, sect. *Montbretia*, Ericaceae, South Africa.

INTRODUCTION

In this article the remaining two sections of the genus *Tritonia*, namely sections *Subcallosae* and *Montbretia* are revised. The species of these two

Accepted for publication 30th May, 1983.

sections are widely distributed in the summer rainfall regions of South Africa, as well as in regions which, although often incorporated with the winter rainfall region, may also receive rain in any season of the year (southern Cape Province, Little Karoo and Namaqualand (Figs 15, 16, 21, 22). Unlike sections *Tritonia* and *Pectinatae*, they do not extend into the winter rainfall region proper, i.e., the extreme south western Cape Province. Only two species, namely *T. moggii* and *T. laxifolia*, occur beyond the borders of South Africa, as far north as Zambia and Tanzania. No species of *Tritonia* occurs in West Africa, and the few species north of the equator which were described as *Tritonia*, belong to other genera.

In both sections now under consideration, the length of the perianth tube varies from species to species, being shorter than the segments in a few species, equal to in others, and up to several times the length of the segments in still others. The degree of zygomorphy of the flowers differs in the two sections, as well as the development, size and shape of the outgrowths, known as calli, on the anticus perianth segments.

Section *Subcallosae*, established here, incorporates species which sometimes show small vestigial calli, usually in the form of low ridges, on one or sometimes all three anticus perianth segments. Its species have flowers with slight zygomorphy. The section can be regarded as the most primitive of the genus, forming a link with the other sections.

Section *Montbretia* comprises the most highly developed species of the genus. The flowers show a decided zygomorphy, as in sections *Pectinatae* and *Teretifolia*, and well-developed calli, 1–5 mm high, occur on the three anticus perianth segments, or rarely on the median one only.

Montbretia was established as a genus by A. P. De Candolle (1803) for two species of *Gladiolus* with calli. There was uncertainty about the rank of this taxon from the time that Bentham and Hooker filius (1883) brought it to the synonymy of *Tritonia*. See further under section *Montbretia*.

A revised key to the five sections is again given, to help in distinguishing the sections.

KEY TO THE SECTIONS

1. Flowers almost regular (rarely completely regular – *T. dubia*) with spreading perianth segments; stamens randomly curved (rarely erect), with anthers not contiguous and not all facing the anterior side of the flower:
 2. Perianth tube shorter than or sometimes subequal to the segments; leaves lanceolate, ensiform, flat 1. Sect. **Tritonia**
 2. Perianth tube longer than the segments; leaves linear, striate (when dry) and subterete or compressed cylindrical (fresh) 4. Sect. **Subcallosae**
1. Flowers zygomorphic with the posticus perianth segment usually widest; stamens curved towards the posticus segment with anthers contiguous, facing the anterior side of the flower:
 3. Spike dense, curved slightly at its base to give it an almost pectinate ap-

pearance: flowers white, cream or pale pink with reddish honey guides in the throat; leaves with crisped-undulate or inrolled margins or with four longitudinal ribs or flanges. 2. Sect. **Pectinatae**

3. Spike lax or sometimes dense, erect or suberect, secund or distichous, not pectinate; flowers red to orange, yellow or sometimes pale, often with yellow in the cup, sometimes with a callus on the lower perianth segments; leaves linear to lanceolate or ensiform, rarely undulate or filiform:
 4. Leaves filiform, terete or subterete, wiry, striate when dry 3. Sect. **Teretifoliae**
 4. Leaves linear to lanceolate or ensiform, rarely spirally twisted with undulate margins:
 5. Perianth with a well-developed callus on the three, or sometimes only the median, anterior segments 5. Sect. **Montbretia**
 5. Perianth without calli or with a low ridge on the median or rarely all three anterior segments 4. Sect. **Subcallosae**

KEY TO SECTION *SUBCALLOSAE*

1. Leaf margins straight:
 2. Leaves compressed cylindrical to subterete, slightly swollen (fresh), linear and striate (dry); flowers almost regular with long perianth tube; stamens almost central with anthers facing outwards 10. **T. bakeri**
 2. Leaves linear-lanceolate to linear, thin and flat, with a prominent middle vein and sometimes a prominent vein near each margin; flowers zygomorphic with long or short perianth tube; stamens curved towards the posterior side of the flower, with anthers unilateral, facing the anterior side:
 3. Perianth tube at least 1,5 times the length of the segments; leaves without a prominent vein near the margins:
 4. Outer bract, of the lower flowers especially, acuminate or rarely with three acuminate tips close together 12. **T. flabellifolia**
 4. Outer bract 3- or sometimes 2-toothed or irregularly toothed 11. **T. pallida**
 3. Perianth tube subequal to, or slightly longer or shorter than the segments; leaves with a prominent vein near each margin:
 5. Flowers cream, straw-coloured or pale yellow, usually with dark veining, sometimes with apricot or orangy tints towards the perianth tips or outside; flowering period August to November (to December) 13. **T. lineata**
 5. Flowers red, orange-red or pink, rarely with dark veining; flowering period (December to) January to April 14. **T. disticha**
1. Leaf margins undulate **T. undulata**
(see under SPECIES INSUFFICIENTLY KNOWN)

KEY TO SECTION *MONTBRETIA*

1. Leaves with undulate margins, sometimes spirally twisted ... 20. **T. watermeyeri**
1. Leaves with straight margins, not spirally twisted:
 2. Perianth tube (1,5-)2-3(-4) times the length of the segments:
 3. Flowers somewhat salver-shaped at noon, with almost equal perianth segments; leaves slightly succulent; Richtersveld, Namaqualand:
 4. Style 18-25 mm long; perianth tube 1,5-2 times the length of the segments 25. **T. delpierrei**
 4. Style 32-40 mm long; perianth tube 3-4 times the length of the segments 26. **T. marlothii**

3. Flowers somewhat 2-lipped or funnel-shaped, with the posticous perianth segment often widest; leaves not succulent; southern and eastern Cape Province, Karoo and Mozambique:
 5. Perianth red, orange-red or pink:
 6. Perianth tube less than 20 mm long, 1.5 to almost 2 times the length of the segments; perianth dark red, drying to a blackish purple-red; eastern Cape Province 23. *T. atrorubens*
 6. Perianth tube more than 20 mm long, about twice the length of the segments; perianth salmon-pink or orange-pink; Mozambique 24. *T. moggii*
 5. Perianth bright yellow or brownish-yellow, sometimes apricot or "cream and orange":
 7. Leaves suberect or sometimes spreading; perianth bright yellow, somewhat 2-lipped; posticous segment erect (porrect) and other segments spreading; southern and south eastern Cape 16. *T. chrysanthia*
 7. Leaves usually strongly reflexed; perianth brownish-yellow, apricot or "cream and yellow", with dark veins, funnel-shaped, segments often reflexed; Great Karoo 27. *T. karooica*
2. Perianth tube nearly equal to or (slightly) shorter than the segments:
 8. Scape not extending above leaf bases; inflorescence with 2-4 flowers each terminal on a short stalk hidden by leaf bases; leaves reflexed 28. *T. florentiae*
 8. Scape extended, usually longer than leaves; inflorescence a simple or branched spike with several flowers; leaves suberect or spreading:
 9. Leaves linear, (0.5-)2-4(-6) mm wide:
 10. Plants not more than 300 mm long; leaves somewhat flaccid; southern Cape 17. *T. parvula*
 10. Plants (250-)300-900 mm long; leaves firm; northern Cape and Transvaal:
 11. Perianth tube 8-10 mm long, about half the length of the segments; leaves with a prominent vein near each margin; north eastern Cape 21. *T. drakensbergensis*
 11. Perianth tube (10-)14-18 mm long, subequal to or slightly longer or rarely shorter than the segments; leaves striate when dry; Transvaal 22. *T. nelsonii*
 9. Leaves lanceolate, ensiform or linear-lanceolate, with widest leaves usually more than 5 mm in width (except *T. strictifolia*):
 12. Flowering period spring or early summer; capsules 7-10 mm long:
 13. Leaves usually erect, (40-)60-90×2-5 mm, with a prominent vein near each margin; callus on the anticus perianth segments high and narrow 18. *T. strictifolia*
 13. Leaves suberect or spreading, longer than 100 mm, usually wider than 5 mm, usually without a prominent vein near the margins, calli disc-shaped (as high as long), rarely high and narrow 15. *T. securigera*
 12. Flowering period autumn, sometimes late summer or early winter; capsules 10-15 mm long, erect, pressed against the rachis 19. *T. laxifolia*

4. Section SUBCALLOSAE DeVos, sect. nov.

Folia lanceolata vel linearia, interdum subteretia, subsucculenta, interdum nervo prominenti prope margines. *Flores* zygomorphi vel interdum fere regulares, plerumque infundibulares, rubri vel miniati vel flavi vel albi, tubo perianthii infundibulari vel pro parte majore tubiformi, parum brevior vel ad 2–3-plo longior segmentis: saepe segmento antico medio vel interdum omnibus tribus segmentis anticis callo vestigiali vel crista humili praeditis. *Stylus* et *stamina* segmentum posticum versus curvata vel interdum fere ad centrum posita.

Type species: Tritonia lineata (Salisb.) Ker-Gawl.

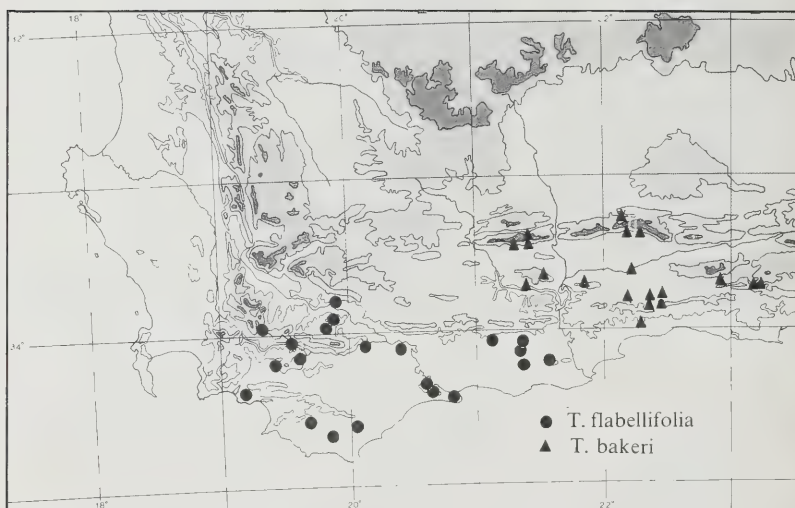
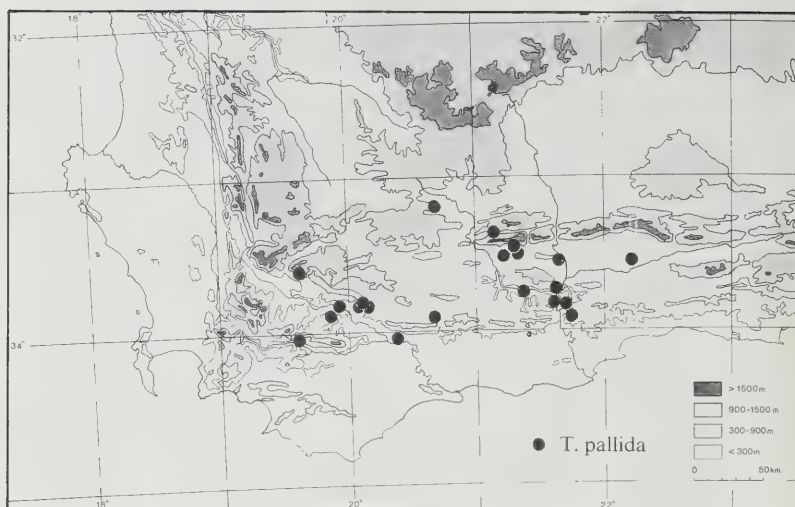
Leaves lanceolate to linear, sometimes subterete and slightly succulent, sometimes with a prominent vein near the margins. *Flowers* zygomorphic or sometimes almost regular, usually funnel-shaped, red, orange-red, pink, yellow or white. *Perianth tube* funnel-shaped or for the greater part tubular, slightly shorter to 2–3 times longer than the segments; *segments* subequal, oblong to obovate-oblancheolate, usually spreading, often with a vestigial callosus or low ridge on the median anticus, or sometimes on all three anticus segments. *Style* and *stamens* curved towards the posticus segment or sometimes almost central. *Anthems* facing the anterior side of the flower or sometimes outwards.

Distribution: Widely distributed in southern districts of the Cape Province from Caledon to George and in the Little Karoo and Langkloof; also in the eastern parts of South Africa from Port Elizabeth, throughout the Transkei and Natal to the south eastern border of Transvaal and north eastern Orange Free State, as well as in Lesotho and Swaziland; not extending into the Great Karoo or the south western corner and western part of the Cape Province (Figs 15, 16).

Three species, namely *T. bakeri*, *T. pallida* and *T. flabellifolia*, mainly from the southern Cape Province, are winter rainfall species, sprouting in autumn and flowering in spring and early summer. *T. lineata* is widely distributed in the eastern summer rainfall regions of South Africa and also occurs within the eastern limits of the winter rainfall region. It, too, has the winter rainfall habit of sprouting in autumn and flowering in spring and early summer. The closely related *T. disticha* which is more or less sympatric with *T. lineata*, flowers in summer.

The species *T. undulata* is known only from its type specimen in Burman's collection in Geneva, with a locality indicated merely as Caput bonae Spei. It perhaps fits best in this section. See under SPECIES INSUFFICIENTLY KNOWN.

In three species, namely *T. pallida*, *T. lineata* and *T. disticha*, a small



G.P.S. (L)

FIG. 15
Geographical distribution of *Tritonia*, section *Subcallosae*: *T. pallida*, *T. flabellifolia*, *T. bakeri*.

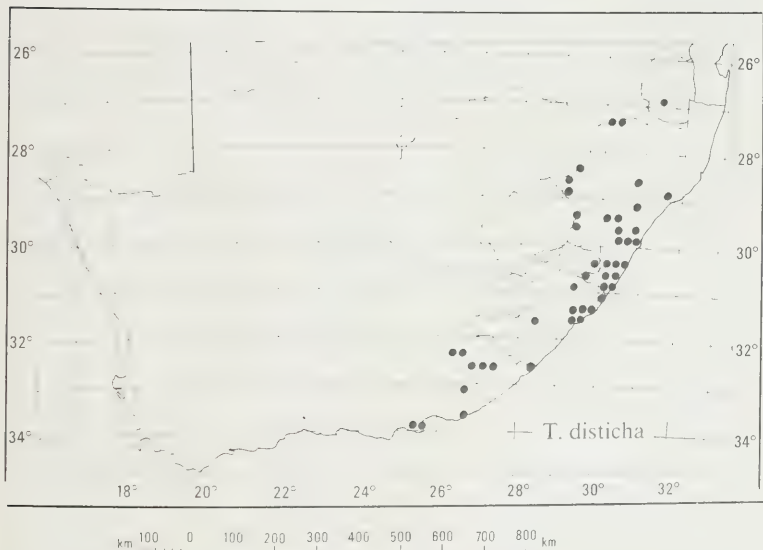
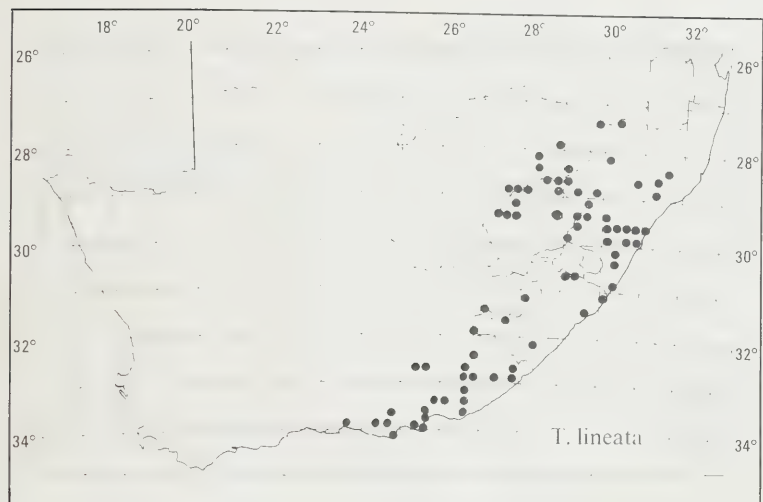


FIG. 16

Geographical distribution of *Tritonia*, section *Subcallosae*: *T. lineata*, *T. disticha*.

vestigial callus, usually in the form of a low ridge, is often present on the median, or sometimes all three, anticus perianth segments. The perianth tube is short in the two eastern species and long in the southern Cape species.

The section seems to form a link with the other sections of the genus and its two eastern, widely distributed species may possibly be considered the most primitive species of the genus. The perianth is not as strongly zygomorphic as in sections *Montbretia*, *Pectinatae* or *Teretifolia*.

The section comprises six out of the 20 species of Baker's subgenus *Tritonia Proper* (1896). Ten of this score of species, however, do not belong to *Tritonia*, and the remaining four species in the subgenus have now been removed to three other sections of *Tritonia*.

Leaf anatomy. Some interesting anatomical features are shown within this section. In *T. bakeri* the long, narrow leaves are compressed cylindrical or subterete, storing a small amount of water. The epidermis of the leaf margins is not palisade-like and thickened as in most species of *Tritonia* (De Vos, 1982a). In *T. lineata* and *T. disticha* the leaves have, in addition to their prominent middle vein, a strong vein near each margin, and the epidermis contains large amounts of tanniferous material often causing the leaves to become dark brown on drying out. The strong submarginal veins remain pale and are especially prominent in the dry state.

10. ***Tritonia bakeri*** Klatt in Abh. naturf. Ges. Halle **15**: 358 (1882), non Klatt 1895.

Plants (270-)400-700(-800) mm long. *Corm* depressed globose, 15-30 mm diam., tunic fibres fine, irregularly reticulate, subparallel in the lower part. *Scape* simple or branched, suberect or slightly flexuose, (200-)400-700(-800) mm long, with a collar of old leaf bases around its base. *Leaves* 4-7 or more, compressed cylindrical or subterete, water storing, rigid, acute or acuminate, erect or suberect, (150-)200-300(-600) × 1-2(-3) mm, striate when dry, sometimes as long as the scape; cauline leaves 1-2, subulate, to 150 mm long. *Spike* 1-2(-3)-branched, distichous, lax, with (3-)6-10 flowers. *Bracts* membranous, papery, with brown and sphacelate upper part, (6-)10-15(-18) mm long; *outer* 2-3-toothed, or irregularly toothed or obtuse, the median tooth sometimes reduced, veined; *inner* bidentate or bifid with acuminate teeth, 2-veined, with papery margins. *Flowers* almost regular, often somewhat salver-shaped, suberect,

FIG. 17

Tritonia bakeri subsp. *bakeri*: a, plant and front and side view of flowers; b, outer (left and lower) and inner (right) bract; c, flower half in a median cut. (De Vos 2413, 2414).



(35-)50-75(-90) mm long, cream, creamy-yellow, or mauvish-pink, the three outer segments with dark veins outside. *Perianth tube* (20-)30-45(-55) mm long, tubular but widening in the upper quarter to 7 mm diam., almost straight; *segments* oblanceolate-oblong or oblanceolate-obovate, obtuse to subobtuse, spreading, subequal in length, (15-)20-25(-30) \times (5-)7-10 mm, with the posticous segment 8-14 mm wide. *Stamens* erect, almost in the centre of the flower; *filaments* (8-)15-20(-25) mm long, erect; *anthers* 5-10 mm long, straight or curved, facing outwards, violet, reaching halfway or almost to the tips of the perianth segments; pollen violet or pale. *Style* (27-)35-60(-80) mm, erect; *stigmatic branches* 3-5 mm long, reaching or overtopping the anthers. *Capsules* obovoid, 12 mm long; *seeds* black, 2 mm diam. *Chromosome number* $2n = 22$.

Flowering period: October to early December.

Distribution: chiefly in the Little Karoo and Langkloof, also in the Cape south coastal districts from George to Riversdale (Fig. 15).

This species is distinguished by its narrow compressed-cylindrical or subterete leaves which store some water and become striate when dried out, and by its lax, distichous spike with almost regular, long-tubed, pale flowers. Morphologically it stands nearest *T. pallida* from which it differs in its narrower leaves, nearly regular flowers with the stamens and style placed almost symmetrically in the centre of the flower, and in its perianth without calli. Its distribution overlaps that of *T. pallida* in the Ladismith district. From *T. cooperi*, which also has narrow leaves, it differs in its lax distichous spike with its almost regular flowers and in its leaves which are not X-shaped or H-shaped in transverse section.

The younger Linnaeus's brief description of *Gladiolus longiflorus* (1781), based on a Thunberg specimen, seems to match *T. bakeri*. There are no Thunberg specimens so named in the Linnaean herbarium (LINN), but only specimens of Sparmann which are, however, *Acidanthera* (N. E. Brown, 1928). One of Thunberg's two sheets in UPS, named *G. longiflorus* α and β respectively (nos 1040 and 1041) must therefore be regarded as the type. They are, however, two species, α being *T. bakeri* and β *T. cooperi*. Linnaeus's diagnosis is so short that it fits both α and β equally well. Three years later Thunberg gave a more detailed description of *G. longiflorus* in *Dissertatio de Gladiolo* (1784), which fits his specimen no. 1041, i.e. *T. cooperi*, best. This then was chosen as lectotype of *G. longiflorus* (De Vos, 1982b).

Specimens collected by Oldenburg and Masson at the Cape were named *G. striatus* by Solander, a manuscript name which Baker (1876) published as *Montbretia striata*. When Klatt (1882) transferred this species to *Tritonia*, he could not use the combination *T. striata* for it, as this was a later homonym

of *T. striata* (Jacq.) Ker-Gawler (1805) (which is *Babiana striata*). He therefore renamed the species *T. bakeri*. But in 1895 he used the name *T. striata* for it, and identified the central African species which Baker (1875) had described as *Montbretia laxifolia* Klatt, as *T. bakeri*. Klatt's *T. bakeri* of 1882 and 1895 are therefore two different species.

The type of *T. bakeri* at BM (sub *Montbretia striata*) comprises three plants with flowers which are rather small compared with numerous later collections of the species, and which resemble the type of *T. lilacina* to some extent. The latter differs in its pale mauvish-pink perianth and in the slightly smaller size of the floral organs. In some herbaria specimens of *T. bakeri* were identified as *T. lilacina*. The two species are so closely related that they are now regarded as conspecific, and *T. lilacina* is transferred to *T. bakeri* as subspecies *lilacina*.

KEY TO THE SUBSPECIES

Flowers (50–)65–80(–90) mm long, cream or creamy-yellow a. subsp. **bakeri**
Flowers 35–50 mm long, pale mauvish-pink or sometimes cream . . . b. subsp. **lilacina**

a. subspecies **bakeri**

Tritonia bakeri Klatt in Abh. naturf. Ges. Halle **15**: 358 (1882), non Klatt 1895; Bak. Handb. Irid. 193 (1892) & in Fl. Cap. **6**: 123 (1896) in part, excl. *Zeyher 4017*; N.E.Br. in J. Linn. Soc. **48**: 25 (1928). Type: Promont. b. Spei, Oldenburg & Masson (BM, holo-) – “Promont. b. Spei” probably refers to the Cape in general.

Gladiolus striatus Soland. ined. in Hb. Banks; non Jacq. (1789).

Montbretia striata Soland. ex. Bak. in J. Bot. Lond. **14**: 337 (1876) & in J. Linn. Soc. **16**: 168 (1877). Type as for *T. bakeri*.

Tritonia striata (Bak.) Klatt in Dur. & Schinz, Consp. Fl. Cap. **5**: 208 (1895) in part, excl. syn. *T. capensis* & *Gladiolus roseus*; hom. illeg., non Ker-Gawler (1805) (= *Babiana striata* (Jacq.) G. J. Lewis).

Gladiolus longiflorus L.f. Suppl.Pl. 96 (1781) in part, excl. lectotype (= *T. cooperi*); Thunb. Diss. Gladiolo **19** (1784) & Prodr. Cap. **8** (1794) in part, excl. syn. Berg. & Delar. & Thunberg Herb. spec. β ; non Jacq. (1789) nec Vahl (1805).

Tritonia longiflora (L.f.) sensu N.E. Br. in J. Linn. Soc. **48**: 25 (1928) in part, excl. Hb. Thunberg spec. β ; non Ker-Gawl. (1805) nec Ait. (1810).

T. longituba R. C. Foster in Contr. Gray Herb. N. S. **114**: 45 (1936) in part, excl. Hb. Thunb. spec. β .

Fig. 17.

Flowers (50–)65–80(–90) mm long, cream or creamy-yellow. Perianth tube (30–)40–45(–55) mm long, ca. (1.5–)2 times the length of the segments;

segments 18–25(–30) mm long, 7–10 mm wide, with the posticous segment up to 12 mm wide. *Style* (40–)50–65(–70) mm long.

CAPE—3321 (Ladismith): Seweweekspoort (-AD), *Wall s.n.*, 14/11/38 (S), *Wurts 1221* (NBG); Elandsberg, *Wurts 1190* (NBG); Southern side of Seweweekspoort, *Delpierre s.n.* sub *De Vos 2436* (STE); Outside Waterkloof, Ladismith (-CB), *Gillett 1913* (BOL, STE), *De Vos 2413* (STE); Hoekoe, *De Vos 2414* (STE); Poort, *Taylor 8978* (STE); Vanwyksdorp, *Compton 3878* (BOL), *Archer 686* (BOL); 2 mls ENE of Vanwyksdorp, *Acocks 20784* (PRE); Rooiberg Pass, ridge W of summit (-DA), *Oliver 5291* (PRE, STE), *Wurts 1653* (NBG); Rooiberg, Nicolaaskloof, *Thompson 3349* (STE).

—3322 (Oudtshoorn): Congo Caves (-AC), *Oliver* NBG 63028; N side of Outeniquas nr Moerasrivier (-CC), *Esterhuysen 19488* (BOL); Zebra (-CD), *Esterhuysen 19357* (BOL); Outeniqua Pass, *Loubser 2078* (NBG); Camfer, *Esterhuysen 7106* (BOL); 4,2 miles WNW of Camfer station, *Acocks 23071* (PRE); Laudina (-DB), *Esterhuysen 6365* (BOL);

—3323 (Willowmore): Hills nr Avontuur (-CA), *Fourcade 3166* (BOL, PRE, STE, MO), *Marloth 10937* (PRE); Uniondale poort, *Acocks 19975* (PRE); Foothills of Kammanassie Mts nr Avontuur, *Esterhuysen 16479* (BOL); Prope Avontuur, *Bolus 2483* (K); Hills S of Haarlem (-CB), *Fourcade 3496* (STE); Misgund hills (-CD), *Esterhuysen 6951* (BOL), *Fourcade 5477* (STE).

—3419 (Caledon): Zwellendam am Berge bei Puspasvalei (-BA), *Ecklon & Zeyher Irid 96* (MO, not G).

—4322 (Mossel Bay)—3322 (Oudtshoorn): Mossel Bay to George, *Barker 7722* (NBG).

Without precise locality: *Drège 8409* (G, L, K); *Burman* (G); *Thunberg 1040* (UPS) sub *Gladiolus longiflorus*.

b. subspecies ***lilacina*** (L.Bol.) De Vos, stat. nov.

T. lilacina L. Bol. in Ann. Bol. Herb. 2: 161 (1918). Type: Cape, exhibited at the Cape Town wild flower show among plants sent from Riversdale, BOL 13755 (BOL, holo.-).

Icon: Coloured drawing by M. Page in BOL.

Flowers 35–50 mm long, pale mauvish-pink with fine purplish veins outside on outer segments, or sometimes cream. *Perianth tube* 20–30 mm long, ca. 1,5 times the length of the segments; *segments* 15–22 × 5–8 mm, with the posticous segment up to 10 mm wide. *Style* 27–35(–40) mm long.

CAPE—3322 (Oudtshoorn): Swartberg Pass (-AC), *Wall s.n.*, 13/11/38 (S); Congo valley mts (-AD), *Marloth 7554* (PRE); Grootkruis, *Thorns* NBG 63029; Oudtshoorn (-CA), *Yeoman* NBG 1717/25 (BOL, NBG), *Deas* SAM 11640, *Jenner 252* (BOL).

Without precise locality: Sent to Cape Town wild flower show, Oct. 1914, 1916; probably ex Oudtshoorn, BOL 13370, BOL 14683 (SAM); ex Riversdale, BOL 13755.

11. *Tritonia pallida* Ker-Gawl. in Curtis's bot. Mag. sub t. 1275 (1810).

Plants (150-)200-400(-600) mm long. *Corm* ovoid, 10-20 mm diam., tunic fibres fine, reticulate. *Scape* (150-)200-400(-600) mm long, often somewhat flexuose or curved, often with one or several branches. *Leaves* ca. 5-6, linear-lanceolate, curved or suberect, acute or acuminate, (100-)150-300(-500) \times 8-15(-25) mm, with a slender middle vein, reaching to the base of the spike; cauline leaves 2-3, subulate, 15-30(-50) mm long. *Spike* distichous, simple or with 1 or more branches, rather lax, with 4-8 or more flowers. *Bracts* membranous, ovate or ovate-lanceolate, straw-coloured, (7-)12-20 mm long; *outer* minutely 3-toothed or sometimes 2-toothed or irregularly toothed, veined, finely sphacelate upwards; *inner* bidentate or shortly bifid, with wide papery margins, 2-veined, sometimes slightly shorter than the outer. *Flowers* zygomorphic, (40-)55-80(-100) mm long, suberect, white or cream or sometimes pale lilac, greenish-yellow in the throat, with purple veins on the tube. *Perianth tube* (25-)35-65(-75) mm long, tubular, slightly curved, widened in the upper quarter to 5-8 mm diam., often slightly pouched on the anticous side; *segments* unequal, obtuse, (8-)10-17(-20) mm long, median posticous segment erect, obovate or suborbicular, (7-)10-13 mm wide, lateral posticous segments spreading, oblong, 4-8 mm wide, anticous segments spreading, oblanceolate-obovate or oblong, 4-6 mm wide, often with a long, low yellow-green excrescence (callus) in the throat. *Stamens* curved against the posticous segment; *filaments* (7-)10-15 mm long, white; *anthers* 5-8 mm long, sometimes with curved tips, mauve to purple, reaching halfway up the perianth segments, pollen purple. *Style* (32-)50-75(-85) mm long; *stigmatic branches* 2-4 mm long, reaching the anther tips or higher. *Capsules* 12-20 mm long, ellipsoid; *seeds* brown, shiny with a reticulate-foveate testa. *Chromosome number* $2n = 22$.

Flowering period: September to November.

Distribution: Little Karoo from Montagu to Ladismith, and coastal districts from Caledon to Riversdale (Fig. 15).

This species is distinguished by its pale long-tubed flowers, often with a low, greenish-yellow callus on the median or on all three anticous perianth segments, and by linear-lanceolate, often somewhat spreading leaves. The typical subspecies can easily be confused with *T. flabellifolia* which has almost similar flowers and habit. *T. pallida* differs in its shorter outer bracts which are three-toothed or irregular at the top; the perianth usually has small calli and the leaves are generally wider and, when dry, not as brown as in *T. flabellifolia*.

The small median excrescences (calli) in the throat on the anticous segments vary in number, size and shape, from a low median ridge on each an-



ticous segment to a semi-orbicular (fide L. Bolus, 1926) callus on the median segment and a low callus (or none) on the two lateral anticous segments. These calli are not obvious in dried material.

Jacquin (1789) figured two long-tubed Iridaceous species as *Gladiolus longiflorus* (Ic. t. 262 and 263), erroneously identifying them with *G. longiflorus* L.f. and *G. longiflorus* Thunb., t. 262 being the present species and t. 263 *Ixia paniculata*. Willdenow (1797) transferred both to *Ixia* as *I. longiflora*, citing Jacquin's t. 262 under his var. α which further comprised several other species. Vahl (1805) also united the two taxa, citing Jacquin's t. 262 as his var. β of *Gladiolus longiflorus*.

Ker-Gawler (1810), on transferring Jacquin's *G. longiflorus* (Ic. t. 262) to *Tritonia*, could not use the combination *T. longiflora* for this species, as he had already incorrectly used the name in 1805 for *Ixia paniculata*. He therefore named it *T. pallida*, citing Jacquin, as well as Willdenow's var. α and Vahl's var. β . Baker, in his treatment of *T. pallida* (1877, under *Montbretia*; 1892, 1896) correctly excluded *G. longiflorus* L.f. from the citations as he realised that Jacquin's and the younger Linnaeus's *G. longiflorus* were not the same species.

KEY TO THE SUBSPECIES

- Flowers longer than 55 mm, with the perianth tube three to four times as long as the segments a. subsp. **pallida**
 Flowers shorter than 50(–55) mm, the perianth tube ca. twice (or less) as long as the segments b. subsp. **taylorae**

a. subspecies **pallida**

Tritonia pallida Ker-Gawl. in Curtis's bot. Mag. sub t. 1275 (1810); Bak. Handb. Irid. 192 (1892) & in Fl. Cap. 6: 122 (1896); Klatt in Abh. naturf. Ges. Halle 15: 358 (1882) & in Dur. & Schinz, Consp. Fl. Afr. 5: 206 (1895). Iconotype: Prom. b. Spei. Jacquin Ic. t. 262 (1789) sub *Gladiolus longiflorus* (lecto-).

Montbretia pallida (Ker-Gawl.) Bak. in J. Linn. Soc. 16: 168 (1877).

Gladiolus longiflorus L.f. sensu Jacq. Ic. t. 262 (1789) & Coll. 5: 23 (1796), excl. syn.; non L.f., nec. Thunb.

G. longiflorus var. β Vahl, Enum 2: 111 (1805).

Icones: Jacq. Ic. t. 262; Lewis, ined., in BOL; this work Fig. 18.

FIG. 18

Tritonia pallida: a. plant and front view of flower; b. outer (left) and inner (right) bract; c. flower half in a median cut; d. capsules; ca. low ridge-like callus. (De Vos 2412, Loubser 2254).

Bracts (8-)12-20 mm long. *Flowers* (55-)70-90(-100) mm long, white or cream, slightly greenish-yellow in the throat. *Perianth tube* (45-)55-65(-75) mm long, 3-4 times longer than the segments; *segments* sometimes with a small callus on one, or all three, anticous segments. *Filaments* (10)13-15 mm; *anthers* 7-8 mm, purple. *Style* (55-)60-75(-85) mm long.

CAPE—3319 (Worcester): Prope Robertson (-DD), *Marloth 8001* (PRE).

—3320 (Montagu): Montagu Division, *Compton 3887* (BOL, NBG, PRE); Laingsburg, Whitehill (-BA), *Barker 4881* (NBG); Montagu (-CC), *Taylor 4034* (NBG), *Archer 536* (BOL); Fonteinkloof, Montagu, *Lewis 4459* (SAM, NBG); Beyond Kogmanskloof, *Middlemost SAM 68460*; Wildehondskloof, Barrydale side, *Goldblatt 2845* (MO); Barrydale (-DC), *Hafström & Acocks 281* (PRE), *Galpin 4708* (PRE, GRA), *Sorensen 315* (C).

—3321 (Ladismith): Vleiland, N of Klein Swartberge (-AC), *Thompson 3182* (PRE, STE); Between Laingsburg & Ladismith, *Loubser 2254* (STE); Ladismith (-AD), *Bayliss 2436* (NBG); 9 mls W of Ladismith, *Salter 6326* (BOL); 3,4 mls from Ladismith to Barrydale (-CB), *Marsh 1425* (PRE, STE, S), *De Vos 2412* (STE); 7 mls E by S of Ladismith, *Acocks 20629* (NBG); Vanwyksdorp (-CD), *Van Breda 748* (PRE), *Archer 687* (BOL, NBG); Calitzdorp (-DA), *Van Breda 748* (PRE); Dwars-in-die Weg, Rooiberg Pass, *Thompson 1431* (PRE, STE); Between Cloete's Pass and Wagenboom, *Goldblatt 4167* (MO).

—3419 (Caledon): Slopes above Greyton (-BA), *Jones s.n.*, Nov (STE).

—3420 (Bredasdorp): Swellendam (-AB), *Archer 535* (BOL).

—3421 (Riversdale): Waterval, Riversdale (-AB), *Muir 3750* (BOL).

b. subspecies **taylorae** (L. Bol.) De Vos, stat. nov.

Tritonia taylorae L. Bol. in Ann. Bol. Herb. 4: 44 (1926). Type: Cape, prope Oudtshoorn, in collibus aridis Bankhoogte, *Taylor 251* (= BOL 12347) (BOL, holo-).

Icon: M. Page, ined. in BOL (flower slightly enlarged).

Bracts 5-10(-13) mm long. *Flowers* 40-45(-58) mm long, pale lilac or cream, sometimes richly veined. *Perianth tube* (25-)30-35(-40) mm long, ca. twice or sometimes 1,5 times the length of the segments; anticous segment sometimes with a semi-orbicular process (f. L. Bolus). *Filaments* 7-10 mm; *anthers* 4-6 mm long. *Style* 32-40(-48) mm long.

CAPE—3319 (Worcester): Slopes of Rabiesberg (-DA), *Lewis s.n.*, 26/9/ 35 (BOL); Dassieshoek Pass (-DD), NBG 91317.

—3320 (Montagu): Montagu Baths (-CC), *Martley BOL 31767*, *Page BOL 31778*; Near Wild Flower Garden, *Hall s.n.*, 21/9/58 (NBG), *De Vos 2411* (STE).

—3321 (Ladismith): Along Ladismith road, 10 mls out, *Lewis BOL 21648* (PRE); Gouritz River valley beyond Cloete's Pass (-DC), *Stayner s.n.*, 20/10/62 (NBG); Cloete's Pass (-DC/-D), *Muir 2392* (BOL).

—3322 (Oudtshoorn): Bankhoogte pr. Oudtshoorn (-CA), *Taylor 251* (BOL).

Without precise locality: *Thunberg* sub *Freesea rosea* (S).

12. *Tritonia flabellifolia* (Delaroche) G.J.Lewis in Jl S. Afr. Bot. 7: 30 (1941).

Plants (200-)250-400(-600) mm long. *Corm* depressed globose, 20-30(-40) mm diam., tunic fibres fine, somewhat reticulate, almost parallel towards the base. *Scape* (200-)250-400(-600) mm long, straight or slightly curved, simple or with 1-3 branches. *Leaves* 6-9, linear-lanceolate or linear, acuminate, suberect, 100-250(-450) \times (2-)4-6(-10) mm, reaching to the base of the spikes, drying to a golden-brown or nut-brown, with a pale middle vein; cauline leaves few, subulate. *Spikes* 1-3, secund, dense or lax, with 3-7 flowers in a spike. *Bracts* lanceolate with elongated attenuate tips, (10-)15-30(-40) mm long; *outer* acuminate or attenuate or rarely with three acuminate tips close together, with a strong median vein towards the tip, greenish near the base, elongating to 40-70 mm after flowering; *inner* bidentate with acuminate teeth, 2-veined, shorter than the outer bract. *Flowers* zygomorphic, (42-)65-85(-95) mm long, suberect, white, cream or pale pink, with a red stripe or a narrow yellow, red outlined stripe or blotch on the three anticus segments, and often magenta in the throat. *Perianth tube* (25-)45-60(-65) mm long, tubular, widened gradually in the upper quarter to ca. 10 mm diam., (1.5-)2-3 times the length of the segments; *segments* unequal, obtuse, (12-)16-25 mm long, the posticus segment obovate, 10-15 mm wide, the other segments obovate-oblancoate, (5-)7-10 mm wide. *Stamens* curved towards the posticus segment; *filaments* (13-)15-18 mm; *anthers* 5-7(-9) mm long, violet, reaching less than halfway to halfway or higher up the perianth segments, pollen pale. *Style* (30-)55-75(-85) mm long; *style branches* 4-7 mm long, overtopping the anthers and sometimes reaching the tips of the perianth segments. *Capsules* obovoid, 7-10 mm long; *seeds* shiny brown, 1.5 mm diam. *Chromosome number* $2n = 44$.

Flowering period: late September to early December.

Distribution: Cape south coastal districts from Caledon to Riversdale, and to Worcester (Fig. 15).

This species is readily distinguished by its long-tubed zygomorphic flowers that have no calli in the throat, its long, acuminate bracts which elongate considerably after flowering, and by linear or linear-lanceolate leaves which become brown (RHS 174B) when dry and have a slender pale middle vein. The perianth tube is two to three times longer than the segments (or rarely only 1.5 times longer), and the largely membranous bract is longer than the bracteole and somewhat green at its base: it is usually acuminate or rarely, in subspecies *thomasiae*, three-toothed, and is often slightly keeled upwards. In habit and floral characters it resembles *T. pallida* closely, but is distinguished by its bracts.



FIG. 19

Tritonia flabellifolia var. *major*: a, plant and front view of flower; b, outer (left) and inner (right) bract; c, flower half in a median cut; ca, low ridge-like callus. (De Vos 2437).

The species has a long and complicated history. D. Delaroche (1766) described it in his thesis as *Ixia flabellifolia*. N. L. Burman (1768) had no clear idea of Delaroche's species, as he noted under this name that it varied in its whitish and blue flowers; he also described *I. tubulosa*, with two varieties, one of which is the present species. Jacquin (1796) named the species *Gladi-*

olus roseus and Aiton (1810), adopting Jacquin's epithet, named it *Tritonia rosea*. (Klatt later described a different species from the eastern Cape Province as *T. rosea* – a later homonym.)

Ker-Gawler (1803, and again 1813) illustrated and described the plant as *T. capensis*, basing it nomenclaturally on *Houttuynia capensis* Houtt. (1780). Figure 85/3 accompanying Houttuyn's description should be chosen as lectotype, as Houttuyn mentioned that the plant he described was lost. This figure shows a regular flower and can therefore not be present *Tritonia* species.

Bentham and Hooker (1883) were the first to cast doubt on Ker-Gawler's equating the present species with *Houttuynia capensis*, observing (p.706) that the shape of the perianth in Houttuyn's figure agrees badly with *T. capensis*, and that the short spathe fits neither *Tritonia* nor *Acidanthera*. E. D. Merrill (1938) pointed out Ker-Gawler's error (J. Arnold Arbor. 19: 328) and stated that the Houttuyn figure seemed "manifestly to appertain to *Ixia*"; Lewis (1962) identified Houttuyn's plant with its symmetrical flower and equal perianth segments, with *Ixia paniculata* Delaroche, a species that occurs in several forms.

Neither Klatt nor Baker realised Ker-Gawler's misapplication of the name: Klatt (1863) called the present species *T. capensis* and Baker (1877) named it *Montbretia capensis*, after Voigt's transference of it to *Montbretia* (1845). Later (1892, 1896) Baker transferred the species to *Acidanthera*, as *A. capensis*. Lewis, in her revision of *Acidanthera* (1941), transferred the species to *Tritonia*, as *T. flabellifolia* Delaroche, this being its oldest epithet. She observed that although the bract is slightly larger and more acute than is usual in *Tritonia*, the corm, leaf and floral characters, as well as the membranous bract, belong to this genus.

Ecklon (1827) named the species *Freesea secunda*, an illegitimate name as he published no description of the genus (Nordenstam, 1972).

Ker-Gawler (1813) described two varieties of his *T. capensis* in *Curtis's Botanical Magazine*, namely var. *major* figured as t. 618 and var. *minor* (t. 1531). They differ in flower size and colouring and in the marks on the perianth, var. *major* being pale pink with a red margined yellow blotch on each anticus segment; var. *minor* has cream flowers with a narrow red stripe on these segments. Var. *major* varies slightly, as is to be seen in Jacquin's *Icones* t. 261 (1789) which shows a pale pink flower with two red lines on either side of a median yellow line on the anticus segments. Voigt (1845) regarded the two varieties as separate species, naming t. 618 *Montbretia rosea* and t. 1531 *M. capensis*.

As the greater majority of herbarium specimens can readily be separated into the two varieties established by Ker-Gawler (1813), his varieties are upheld. The Burman specimen, as well as the specimens in the Van Royen

herbarium amongst which Delaroche's type material probably occurs, belongs to Ker-Gawler's var. *minor*, and this therefore becomes the typical variety.

A few recent collections by Thomas from the Bot River–Hawston area have flowers with shorter perianth tubes and bracts which are either acuminate or have three acute teeth very close together. They are regarded as a third variety.

KEY TO THE VARIETIES

1. Perianth tube 2–3 times longer than the segments:
 2. Flowers less than 50 mm long, rarely up to 60 mm; perianth tube 25–30(–40) mm long a. var. **flabellifolia**
 2. Flowers (60–)65–75(–95) mm long; perianth tube (45–)50–65 mm long b. var. **major**
1. Perianth tube 1.5 times longer than the segments c. var. **thomasiae**

a. var. **flabellifolia**

Ixia flabellifolia Delaroche Descr. pl. aliq. nov. 24 (1766). Type: s. loc., Van Royen (L, neo-). But see below.

Acidanthera flabellifolia (Delaroche) N.E.Br. in Kew Bull. **1929**: 135 (1929).

Tritonia flabellifolia (Delaroche) G. J. Lewis in Jl S. Afr. Bot. **7**: 30 (1941); Goldbl. & Barnard in Jl S. Afr. Bot. **36**: 310 (1970).

T. capensis (Houtt.) Ker-Gawl. var. *minor* Ker-Gawl. in Curtis's bot. Mag. **37** t. 1531 (1813) in part, excl. basionym *Houttuynia capensis* and *Gladiolus longiflorus*. Iconotype: Curtis's bot. Mag. t. 1531 (lecto-).

T. capensis (Houtt.) Ker-Gawl. sensu Klatt in Linnaea **32**: 757 (1863), excl. syn. *Gladiolus* and Bot. Mag. t. 618; & in Dur. & Schinz, Conspl. Fl. Afr. **5**: 204 (1895), excl. basionym.

Montbretia capensis (Houtt.) Voigt, Hort. Suburb. Calcut. 611 (1845); Bak. in J. Linn. Soc. **16**: 168 (1877), excl. basionym and Bot. Mag. t. 618.

Acidanthera capensis (Houtt.) Bak. Handb. Irid. 187 (1892) & in Fl. Cap. **6**: 133 (1896), excl. cit. Bot. Mag. t. 618 and syn. *Gladiolus*.

Outer bracts 8–15 mm long, acute to acuminate. *Flowers* 42–45(–60) mm long, white, cream or pale pink, the anticous segments with a narrow median red stripe or yellow stripe outlined in red in the throat. *Perianth tube* 25–30(–40) mm long. *Style* 30–35(–45) mm.

CAPE—3319 (Worcester): Between Robertson and McGregor (-DD), *Leipoldt* 3602 (BOL, PRE).

—3320 (Montagu) to —3419 (Caledon): Swellendam bei Berge Puspasvalei Voor-mansbosch, etc. —3419-BA—3320-DC), *Zeyher* 4017 (S).

—3419 (Caledon): Genadendal (-BA), *Prior s.n.* (K); Greyton, *Jones s.n.* (STE).
Without locality: *Van Royen* collection (L); *Burman* sub *Ixia flabellifolia* (G).

Type: N. E. Brown (1929) found four specimens in the Burman collection at Geneva labelled *Ixia flabellifolia* Laroche. He identified three as *Babiana* and the fourth as the true *I. flabellifolia*, as it “so accurately agrees . . . in all characters except the length of the style” with Delaroche’s description of 1766. He indicated this specimen as type, as he believed the label on this sheet to be in the handwriting of D. Delaroche. On my enquiry, Dr. H. M. Burdet of Geneva, specialist in old handwriting, was unable to confirm that this label was indeed in Delaroche’s hand.

Goldblatt and Barnard (1970), in their work on the Iridaceae of Daniel Delaroche’s thesis, state that neither the Burman specimen nor those they found in the Van Royen herbarium in Leiden, have any claim to be the type material. They therefore chose a neotype from amongst the Van Royen specimens, namely one labelled *Tritonia viridi* Ker *proxima* and *Ixia flabellifolia* La Roche (in two different handwritings).

If, however, the label on Burman’s specimen which N. E. Brown identified as type, is indeed found to be in D. Delaroche’s hand, then this specimen must be the lectotype which will supersede the neotype indicated by Goldblatt and Barnard.

b. var. major (Ker-Gawl.) De Vos, comb. nov.

Tritonia capensis (Houtt.) Ker-Gawl. sensu Ker-Gawl. var. *major* Ker-Gawl. in Curtis’s bot. Mag. sub t. 1531 (1813) & Bot. Mag. t. 618 (1803) in part, excl. basionym *Houttuynia capensis*, and *Gladiolus striatus*; & in Kon. & Simms, Ann. bot. 1: 228 (1805). Iconotype: Curtis’s bot. Mag. t. 618 (lecto-).

T. capensis (Houtt.) Ker-Gawl. sensu Klatt in Linnaea 32: 757 (1863) in part, excl. syn. *Gladiolus* and Bot. Mag. t. 1531; & in Abh. naturf. Ges. Halle 15: 358 (1882).

Montbretia capensis (Houtt.) Voigt sensu Bak. in J. Linn. Soc. 16: 168 (1877) in part, excl. basionym *H. capensis*, and Bot. Mag. t. 1531.

Acidanthera capensis (Houtt.) Bak. Handb. Irid. 187 (1892) & in Fl. Cap. 6: 133 (1896), excl. Bot. Mag. t. 1531.

Gladiolus roseus Jacq. Ic. Rar. t. 261 (1789) & Coll. 5: 22 (1796). Iconotype: Ic. t. 261 (lecto-).

Tritonia rosea (Jacq.) Ait. Hort. Kew. ed. 2, 1: 91 (1810), excl. syn. *Houttuynia*; non Klatt (1863, 1895), nec Bak. (1892, 1896).

Montbretia rosea (Jacq.) Voigt. Hort. Suburb. Calcut. 610 (1845); non Bak. 1877 (= *T. disticha* var. *rubrolucens*).

Freesea secunda Eckl. Top. Verz. 30 (1827), nom. illeg., gen. non descr.; Nordenstam in JI S. Afr. Bot. 38: 296 (1972).

Tritonia secunda (Eckl.) Steud. Nom. Bot. ed. 2, 2: 719 (1841) nom. nud.

Ixia tubulosa N. L. Burm. Prodr. Fl. Cap. 1 (1768) in part, excl. lectotype (= *Babiana tubulosa*); N.E. Br. in Kew Bull. 1929: 137. See below.

Icones: Curtis's bot. Mag. t. 618; Jacq. Ic. Rar. t. 261; this work Fig. 19.

Outer bracts (15–)20–40 mm long, acuminate or attenuate. *Flowers* (60–)65–75(–95) mm long, pale pink or white, with a yellow median blotch or stripe often outlined in red on the three anticonic perianth segments. *Perianth tube* (45–)50–60(–65) mm long. *Style* (55–)60–85) mm.

CAPE—3319 (Worcester): Villiersdorp (-CD), *Barnard* BOL 31782; McGregor, foot of Boesmanskloof Pass (-DD), *Lewis* 6203 (NBG, MO); Robertson, *Hall* 719 (NBG); Langvlei, Robertson, *Van Breda* 2063 (PRE).

—3419 (Caledon): Caledon (-AB), *Guthrie* BOL 31781; Between Caledon and Riviersonderend (-BA), *Barker* 6843 (NBG); Am Baviaansberg bei Genadenthal, *Ecklon* 282 (S); Riviersondereinde, *Compton* 21795 (NBG), *Zeyher* 4017 (SAM, K), *Pappe* SAM 21113, 21114; Near Elim (-DA), *Frowein* PRE 16119, *Bolus* BOL 31780; Between Vogelvlei and Wisedrift (-DB), *Mathews* 32 (NBG).

—3420 (Bredasdorp): Dasberg near Stormsvlei (-AA), *Stokoe* SAM 59773; Bontebokpark (-AB), *Marais* 1 (PRE); 13 mls from Port Beaufort towards Malgas (-BC), *Lewis* 6127 (NBG); Potteberg, *David* 292 (NBG); Near Cape Infanta (-BD), *Esteyhuysen* 29358 (BOL, MO); Near Bredasdorp (-CA), *Hafström & Acocks* 2069 (S).

—3421 (Riversdale): Corenterivier farm (-AA), *Muir* 5363 (BOL, PRE, GRA); In lapidosis pr. Riversdale (-AB), *Schlechter* 1815 (PRE, G, K); 5 mls S of Riversdale on Blombos road, *Thomas s.n.* (NBG); Near Zoetmelks River, *Burchell* 6739 (K); Around Albertinia (-BA), *Muir* 1157 (BOL).

Without precise locality: *Irid.* 282 (G); *Burman* (G) sub *Ixia tubulosa*.

Burman's description (1768) of *Ixia tubulosa* is that of two species, and three of the five specimens so named in his collection in Geneva are *Babiana tubulosa* (Burman f.) Ker-Gawler. One of these has been chosen as the type of this name (Lewis, 1959). The other two specimens in the collection are *Tritonia flabellifolia* and *Engysiphon pictus* (Foster) G.J. Lewis.

c. var. *thomasiae* De Vos, var. nov.

Ab aliis varietatibus *Tritoniae flabellifoliae* distinguitur tubo perigonii non nisi 1,5-plo longiore quam segmentis, bractea exteriori aliquando tridentata ad apice, dentibus approximatis, acuminatis.

Type: Cape, Caledon, Protea farm between Hawston and Bot River, *Thomas s.n.* NBG 77202 (NBG, holo-, STE).

Outer bracts 10–25 mm long, acuminate or sometimes with three long

acuminate tips close together, keeled near the tip. *Flower* 50–67 mm long, rose-pink inside, with a yellow blotch outlined in red on the anticous perianth segments, deeper pink outside. *Perianth tube* 30–45 mm long, only ca. 1.5 times the length of the segments. *Style* 45–55 mm.

CAPE—3420 (Caledon): Protea farm, between Hawston and Bot River (-AC), Thomas NBG 70.508, 77.202, 87.945, Thomas s.n., 6/11/64 (STE).

13. *Tritonia lineata* (Salisb.) Ker-Gawl. in Kon. & Sims, Ann. Bot. 1: 228 (1805).

Plants (150–)400–600(–850) mm long. *Corm* shortly ovoid, 10–20 mm diam., sometimes with small cormlet offsets at the base; tunic fibres fine, reticulate, towards the base long-reticulate. *Scape* simple or branched, (150–)400–600(–850) mm long. *Leaves* 4–8, linear-lanceolate or linear-ensiform, (sub)erect or spreading, acute, (40–)150–300(–500) × (2–)7–10(–15) mm, with a prominent vein near each edge and in the middle, usually not reaching the base of the spike, often drying to brown or dark brown with pale veins; cauline leaves 1–3, 25–100 mm long. *Spike* somewhat secund, lax, sometimes with one branch, with (1–2–)7–12 flowers. *Bracts* membranous, usually brown especially in the upper half, 7–10(–12) mm long; *outer* 3–5-toothed with the median tooth sometimes reduced, or irregularly toothed, striate, with a stronger median vein; *inner* bifid with acuminate teeth, with 2 dark veins and papery margins. *Flowers* slightly zygomorphic, funnel-shaped, (25–)30–35(–40) mm long, cream, pale yellow or straw-coloured to pale apricot, with dark veining and sometimes apricot tints outside especially towards the tips of the tepals. *Perianth tube* funnel-shaped, 10–15 mm long, narrow in the lower half, widened to 8 mm diam. upwards; *segments* obtuse, subequal in length, (15–)18–20(–23) mm long, the median posticous segment (8–)10–12(–14) mm wide, obovate-lanceolate, the other segments 5–8(10) mm wide, oblanceolate, sometimes with a low yellow, ridge-like calus on the median anticous segment. *Stamens* curved towards the posticous side; *filaments* 7–10(–12) mm; *anthers* unilateral, 5–9 mm long, pale or with dark lateral stripes, reaching halfway or almost halfway up the perianth segments, pollen cream. *Style* (15–)18–25 mm; stigmatic branches 3–5 mm long, reaching or overtopping the anther tips. *Capsules* subrotund-trigonus or shortly obovoid-trigonus, ca. 8 mm long; *seeds* dark brown, angled, 2.5 mm diam.

Flowering period: August to November (to December).

Distribution: eastern and south eastern Cape Province, Transkei, Natal, north eastern Orange Free State, south eastern Transvaal, and Lesotho (Fig. 16).

This species was first described by Aiton (1789) as var. *stricta* of *Ixia squalida*. Seven years later Salisbury, realising its difference, described it as *Gladiolus lineatus* and cited Aiton's variety. He was followed by Ker-Gawler (1800) who transferred it in 1805 to his new genus *Tritonia*.

The species is distinguished by its short-tubed cream, straw-coloured, yellow or salmon-pink flowers (e.g. RHS 20B, C, 28C, D, 11B, C), "finely and curiously pencilled with dark lines" (Ker-Gawler, 1800), and by leaves which show three prominent veins, two of which are near the leaf margins, and especially prominent in the dried state. A small yellow area occurs in the throat on the anticus perianth segments of the cream and straw-coloured flowers, and sometimes the median anticus segment has a low callosity in the form of a longitudinal ridge. It differs from the closely related *T. disticha* in flower colouring and slightly shorter perianth tube, as well as in its different flowering period.

Specimens with cream or straw-coloured flowers, often with orangy tints on the reverse, occur in the eastern Cape Province and Natal. Such are figured in *Curtis's Botanical Magazine* t. 487 and in Redouté's *Liliacées* t. 55. In herbarium specimens the tepal tips often become pale brown.

Most specimens from the Orange Free State, Lesotho and the Drakensberg region of Natal have pale yellow flowers without orange tints outside, and often with less distinct veining. This form was described as *T. flavida* by Schlechter (1908). Another variation which has pale pink flowers, was described as *T. kraussii* by Baker (1892). These are apparently colour variations only and are not upheld here as separate varieties.

The two specimens which Redouté figured (t. 55 and 400) were described as var. *minor* and var. *major* respectively (*Liliacées* sub t. 400, 1813). There is not enough evidence to uphold these varieties as they are connected by numerous intermediates. But certain collections from the south eastern Cape Province comprise distinctly smaller plants with much shorter and narrower, erect leaves, and these are now described as a separate variety.

KEY TO THE VARIETIES

- Plants more than 300 mm long; leaves more than 150×5 mm, suberect or spreading a. var. **lineata**
 Plants up to 300 mm long; leaves less than 150×5 mm, usually erect b. var. **parvifolia**

a. var. **lineata**

Tritonia lineata (Salisb.) Ker-Gawl. in Kon. & Sims, Ann. Bot. 1: 228 (1805); Ait. Hort. Kew. ed. 2, 1: 91 (1810); Klatt in Linnaea 32: 759 (1863) & in Dur. & Schinz, Conspect. Fl. Afr. 5: 206 (1895); Bak. Handb. Irid. 194 (1892) & in Fl. Cap. 6: 25 (1896).

Gladiolus lineatus Salisb. Prodr. 40 (1796); Ker-Gawl. in Curtis's bot. Mag. t. 487 (1800). Syntypes: sub *Ixia squalida* var. *stricta*, Hort. Kew. 1781 (BM, lecto-) & 1778 (BM). See below.

G. lineatus Salisb. var. *minor* & var. *major*, Red. Lil. 7 t. 400 (1813). Iconotypes: Red. Lil. t. 55 & t. 400 respectively.

Montbretia lineata (Salisb.) Bak. in J. Linn. Soc. 16: 169 (1877), excl. syn. *Ixia thunbergii*.

Tritonixia lineata (Salisb.) Klatt in Abh. naturf. Ges. Halle 15: 357 (1882).

Ixia squalida Ait. var. *stricta* Ait. Hort. Kew. 1: 61 (1789). Syntypes: Hort. Kew. 1778 (BM), 1781 (BM, lecto-).

Gladiolus venosus Willd. Enum. 1: 58 (1809). Type: Cap. b. Spei, Willdenow 929 (B, holo-).

Tritonia catenularis Salisb. in Roy. Hort. Soc. Trans. 1: 319 (1812), nom. superfl. Type as for *G. lineatus*.

Ixia reticulata Thunb. Fl. Cap. ed. 2, 60 (1823). Type: Cap. b. Spei, Thunberg 989 (UPS, holo-).

Tritonia kraussii Bak. Handb. Irid. 194 (1892) & in Fl. Cap. 6: 125 (1896), excl. syn. Type: Natal, summit of Table Mountain, Krauss 200 (K, lecto-).

T. flavida Schlecht. in Bot Jb. 40: 91 (1908). Type: Jolivet, unweit Fairfield, Alexandra Country, Rudatis 91 (B, holo-).

Icones: Curtis's bot. Mag. t. 487; Red. Lil. 1 t. 55 & 7 t. 400; this work Fig. 20.

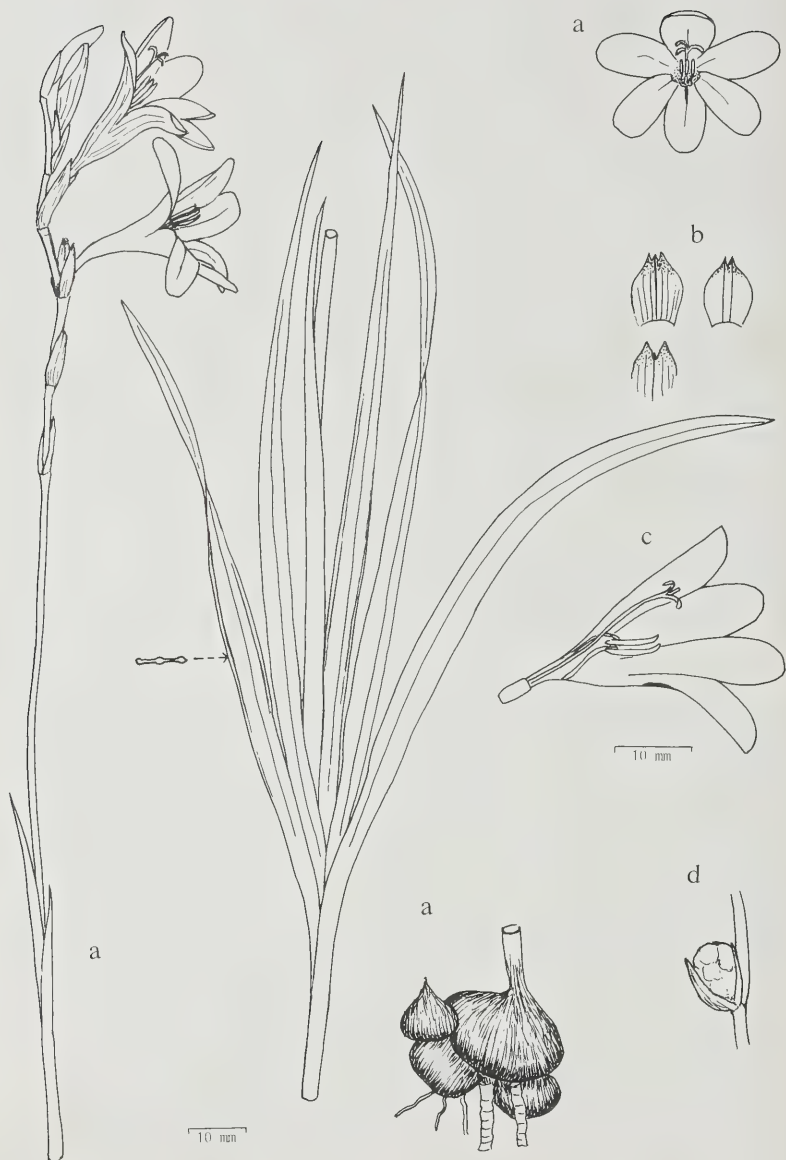
Type: As Salisbury (1796) cited only *Ixia squalida* β Soland. in Ait., the type of the latter in BM is also the type of *T. lineata*. There are two sheets of type material in BM dated 1778 and 1781. The latter, being the better specimen, is chosen as lectotype.

Plants (300-)400-600(-850) mm long. *Scape* (300-)400-600(-850) mm, simple or branched, with 7 or more flowers. *Leaves* linear-lanceolate or linear-ensiform, suberect or spreading, 150-300(-500) \times (5-)7-10(-15) mm, usually not reaching the base of the spike, often drying to brown or dark brown with pale veins. *Style* up to 25 mm. *Chromosome number* $2n = 44$.

Distribution: widespread, from Uniondale and Humansdorp throughout the eastern Cape, Transkei, Natal, north eastern Orange Free State, to south eastern Transvaal and into Lesotho.

TRANSVAAL—2729 (Volksrust): Volksrust (-BD), Sidey 3973 (PRE, S).

ORANGE FREE STATE—2728 (Frankfort): Near Warden (-DD), Hafström & Acocks 332 (PRE).



—2827 (Senekal): Near Meguathling, Clocolan (-DC), *Kinges* 1216 (PRE); Ficksburg (-DD), *Rogers* 15923 (BOL, GRA, Z), *Galpin* 13842 (PRE, S), *Galpin* BOL 31739.

—2828 (Bethlehem): Signal Hill, Bethlehem (-AB), *Potgieter* 216 (PRE); Road Bethlehem to Clarens (-AD), *Van Zinderen-Bakker* 198 (PRE, BLFU); Golden Gate Glen Reenen (-DA), *Liebenberg* 7290 (PRE).

—2829 (Harrismith): Platberg (-AC), *Jacobs* 2272, 3043 (PRE); Harrismith, *Sankey* 292 (K); Kerkenberg, *Van Zinderen-Bakker* 1270 (BLFU).

NATAL—2730 (Vryheid): Paardeplaats 10 mls E of Wakkerstroom (-AD), *Devenish* 103 (PRE).

—2828 (Bethlehem): Royal National Park, Drakensberg (-DB), *Sidey* 2023 (S), *Oliver* 348 (NH); Mont-aux-Sources (-DD), *Guthrie* 4927 (BOL).

—2829 (Harrismith): Cathedral area near hotel (-CC), *Schelte* 834 (NU).

—2830 (Dundee): Airfield (-AA), *Shirley* 126 (NU); Nkandla, 1 ml W of P.O. Qudeni (-DB), *Codd* 6999 (NH, NU).

—2831 (Nkandla): Intunzini (-BC), *Garland* NH 38636; Eshowe (-CD), *Gerstner* 2551 (NH), *Lawn* 167 (NH); Umhlutuzi valley near Eshowe, *Gerstner* NH 22562; Melmoth (-CB), *Porter s.n.*, Sept. 1955 (NBG, STE).

—2929 (Underberg): Impendhle distr, Loteni Nature Reserve (-AD), *Phelan* 106 (NU); Kamberg (-BC), *Wright* 1538 (NU); Sani Pass (-CB), *Gillies* 113 (NU).

—2930 (Pietermaritzburg): Howick (-AC), *Moll* 1003 (NU); Manderston (-CB), *Thomas* 21 (NU); Camperdown (-DA), *Barker* 5310 (NBG); Cato Ridge, *McLean & Ogilvie* NH 27888; Inchanga, *Marloth* 4091 (K); Umzinyati (-DB), *Wood* 11569 (S); Inanda, *Wood* 669 (STE, K); Botha's Hill (-DC), *Hutchinson e.a.* 45 (NH), *Hutchinson* 4693 (K); Krantzklouf (-DD), *Haygarth* 68 (STE); Pinetown, Kloof, *Johnson* 1348 (NH).

—2931 (Stanger): Phoenix Umgebung (-CA), *Schlechter* 3114 (Z); Chatsworth (-CC), *Coleman* 178 (NH).

—3029 (Kokstad): Circa Kokstad (-CB), *Tyson* 507 (BOL, SAM, K), 1105 (BOL, SAM, etc.).

—3030 (Port Shepstone): St. Michael (-AB), *Thode* 5098 (STE); Hlokozi, Alexandra City (-AD), *Rudatis* STE 2371; Jolivet unweit Fairfield, *Rudatis* 91 (B); Mvenyani (-CA), *Bandert* 9 (GRA); Shelley Beach (-CD), *Strey* 9241 (NU, SRGH).

—3130 (Port Edward): Ca 5 mls from Port Edward (-AA), *Hilliard* 1659A (NU).

TRANSKEI—3127 (Lady Frere): Near Cala (-DA), *Royffe* 174 (GRA).

—3128 (Umtata): Pomona, Ugie (-AA), *Gill* 143 (MO).

—3129 (Port St Johns): Ntsubane Forest Sta. (-BC), *Venter & Vorster* 10 (K, SRGH).

—3228 (Butterworth): Idutywa (-AB), *Reynolds* 1041 (BOL).

LESOTHO—2828 (Bethlehem): Leribe (-CC), *Dieterlen* 245 (SAM, K).

—2927 (Maseru): Mamathes (-BB), *Guillarmod* 585 (PRE); Mahlatsa, Berea, *Guillarmod* 1595 (PRE); Molima Nthuse Pass (-BC), *Schmitz* 6230, 6283 (PRE); Rama campus, *Schmitz* 4171 (PRE).

—2928 (Marakabei): Khatleleli (-BD), *Dieterlen* 245 (PRE).

—2929 (Underberg): Sehlabathebe Nat. Park (-CC), *Hoener* 1858 (PRE).

CAPE—3126 (Queenstown): Queenstown distr., *Sidey* 3726 (S); Madeira, Queenstown (-DD), *Thorns* BOL 31740.

—3127 (Lady Frere): Clarke's Siding near Dordrecht (-AC), *Bayliss* 7942 (MO).

FIG. 20

Tritonia lineata var. *lineata*: a, plant and front view of flower; b, outer (left) and inner (right) bract; c, flower half; d, capsule. (*Olivier* 2603).

—3225 (Somerset East): Klein Bruintjieshoogte (-CB), *Drège* 3499 (S); Bosberg (-DA), *MacOwan* 1199 (BOL, K, S).

—3226 (Fort Beaufort): Fairford (-BD), *Cotterrell* 50 (GRA); Alice (-DD), *Goldblatt* 438, 370 (BOL).

—3227 (Stutterheim): Kingwilliamstown (-CD), *Liebenberg* 3141 (K), *Tyson* 3130 (SAM); Komgha (-DB), *Flanagan* SAM 3612; 10 mls from East London to Kingwilliamstown (-DD), *Marais* 448 (BOL, GRA); East London, *Rattray* 192 (GRA), *Sidey* 1145 (S).

—3323 (Willowmore): 3–5 km W of Louterwater (-DC), *De Vos* 2567 (STE).

—3324 (Steytlerville): Near Kareedow (-CD), *De Vos* 2568 (STE); Baviaanskloof (-DA/-DB), *Bayliss* 6882 (MO).

—3325 (Port Elizabeth): Bronne Reservaat (-CD), *Olivier* 2603 (STE); Gravel road SW of Addo village (-DA), *De Vos* 2569 (STE); Port Elizabeth (-DC), *Drège* s.n., Oct. 1908 (GRA); Aerodrome, *Long* 155 (GRA, K); Baakens Valley, *Olivier* 833 (NBG).

—3326 (Grahamstown): Near Alicedale (-AC), *Bayliss* 6814, 7092 (MO); Coldspring, *Dlumane* P62 (GRA); Fort Beaufort road, 10 mls from Grahamstown (-BA), *Bayliss* 2997 (MO, SRGH); Grahamstown (-BC), *Daley* 866 (GRA); Between Blaauw Krantz & Kaffir Drift (-BD), *Burchell* 3710 (K).

—3422 (Mossel Bay): Mossel Bay (-AA), *Wall* 47 (S).

—3424 Humansdorp: Seekoeirivier (-BB), *Montgomery* 1 (STE); Cape St Francis, *Baylis* s.n., 21/10/75 (MO).

Without precise locality: *Pappe* s.n. (SAM); *Drège* 3499c (L); *Irid.* 99 (G, MO), 101 (G), 280 (G); *Thunberg* 989 (UPS); Hb Burman sub *Ixia foliis linearibus* (G); *Burchell* s.n. (K); *Harvey* s.n. (K); *Kolbe* BLFU 1187.

Figure 9592 in *Curtis's Botanical Magazine* (1939–40) is that of a yellow-flowered plant which is named *Tritonia flavida*. It was collected in Natal in 1927 and cultivated for many years in England. It may be the yellow-flowered variation of var. *lineata*, although the stamens are not shown to be contiguous or curved towards the posterior side of the flower.

b. var. **parvifolia** De Vos, var. nov.

A varietate *lineata* foliis brevioribus et angustioribus, plerumque erectis, multo brevioribus quam scapo differt.

Type: Cape: Jeffreys Bay, duineveld, *Fourcade* 3345 (STE, holo-; PRE, K, MO).

Plants 150–200(–300) mm long. *Scape* 150–200(–300) mm long, usually unbranched, with 1–2(–4) flowers. *Leaves* linear-lanceolate, usually erect, (40–)50–80(–150) × 2–5 mm, usually not reaching even near the base of the spike, drying to light brown. *Style* 15–18 mm.

Distribution: south eastern Cape districts of Humansdorp, Uitenhage and Port Elizabeth.

CAPE—3325 (Port Elizabeth): Port Elizabeth, *Holland* BOL 31771; Addo National Park (-DA), *De Vos* 2571 (STE); Zwartkops Rivier (-DB) *Zeyher* 3972 (SAM, K); On the hills of Adow and the fields near the Zwartkop River, *Ecklon & Zeyher* 1021 (GRA partly, PRE, SAM, K), *E. & Z.* 101 (GRA, MO partly, not G). *Perse-*

verance (-DC), *Rodin 1246* (BOL, K, MO); Inter Uitenhage & Bethelsdorp saltpan, *Fries e.a.* (SAM 68099, K).

—3424 (Humansdorp): Jeffreys Bay and Ferreira Town near sea (-BB), *Gillett 2319* (STE); Jeffreys Bay duineveld, *Fourcade 3345* (PRE, STE, K, MO); Humansdorp, *Loubser 881* (NBG).

Compared with the wide range of var. *lineata*, this variety has a restricted distribution in the south eastern Cape Province. It is distinguished by its small erect leaves and by flowers that are identical with the cream and straw-coloured variations of var. *lineata* and often have, like the latter, a small ridge-like callus on the median anticus perianth segment. It is not the same as var. *minor* which was described in Redouté's *Liliacées* 7 sub t. 400. The latter has much longer leaves and is now incorporated with the typical variety.

The leaves of var. *parvifolia* resemble those of *T. strictifolia* and poor herbarium specimens can easily be confused. The flowers, however, are different and the two taxa have now been placed in separate sections of the genus. *T. strictifolia*, with its more zygomorphic flowers and high calli, is closely allied to *T. securigera* and *T. laxifolia*, and has therefore been placed in section *Montbretia*.

14. ***Tritonia disticha*** (Klatt) Bak. Handb. Irid. 193 (1892) & in Fl. Cap. 6: 123 (1896).

Plants (200–)500–800(–1 000) mm long. *Corm* depressed globose to ovoid, 10–30 mm diam.; tunic fibres elongated-reticulate, almost parallel towards the base. *Scape* simple or 1–3-branched, sometimes slightly flexuose, (200–)500–800(–1 000) mm long. *Leaves* 4–8, linear to linear-lanceolate, erect or suberect, acute or acuminate, (250–)350–500(–700) × (5–)8–12(–20) mm, with a strong middle vein and a strong vein near each edge, reaching, or sometimes not reaching, the base of the spike, usually drying to dark brown with pale veins; cauline leaves 2–4, 30–300 mm long. *Spikes* 1–3(–4), at first distichous, later subsecund, lax, with 4–12 or more flowers. *Bracts* membranous, golden-brown, darker brown upwards, with wide papery margins, (8–)10–15(–20) mm long; *outer* ovate or ovate-lanceolate, acute or acuminate or 3-toothed with the middle tooth sometimes reduced, or irregularly toothed, striate, with a strong dark median vein, the lower ones sometimes elongating after flowering; *inner* bidentate with acuminate teeth, with 2 strong dark veins, often slightly shorter than the outer. *Flowers* slightly zygomorphic, funnel-shaped, (20–)25–30(–35) mm long, bright red, orange-red or pink, with a small yellow, sometimes red-margined, blotch on the anticus perianth segments, sometimes with dark veining. *Perianth tube* funnel-shaped, (8–)12–16 mm long, with the basal 3 mm

narrow, widened upwards to 8–10 mm diam., subequal to or slightly longer, or rarely slightly shorter, than the segments; *segments* shortly elliptical or oblanceolate-obovate, obtuse, spreading, subequal in length, (10–)15–18(–20) mm long, the median posticous segment 8–10 mm wide, others 5–6 mm, the median anticous segment sometimes with a low yellow callus. *Stamens* curved towards the posticous side; *filaments* 7–12 mm long; *anthers* 5–7 mm long, curved, pink or yellow, reaching halfway or higher up the perianth segments. *Style* (15–)18–22 mm; *stigmatic branches* 2–4 mm long, usually overtopping the anthers. *Capsules* subglobose or obovoid, ca. 10 mm long; *seeds* brownish-black, shiny, minutely alveolate, 2 mm diam.

Flowering period: (November to) December to February (to March).

Distribution: from the south eastern Cape Province throughout Transkei and Natal to north eastern Orange Free State and south eastern Transvaal, and into Swaziland. (Fig. 16).

This species, which now includes *T. rubrolucens*, is closely related to *T. lineata*, resembling it in general habit and especially in its long, erect or suberect, leaves which have a prominent vein near each edge and large amounts of tannin in the epidermis (De Vos, 1982a), usually causing the leaves, on drying out, to turn dark brown except for their pale veins. The distribution of the two species is almost similar. *T. disticha* differs from *T. lineata* in its red, pink or orange-red flowers with less distinct veining and with a yellow blotch in the throat on the anticous perianth segments, as well as in its different flowering period (summer). Faded herbarium specimens can hardly be distinguished when the flower colouring or flowering period is not mentioned.

The species was first described by Klatt (1863) as *T. rosea*. This name is an illegitimate later homonym of *T. rosea* (Jacq.) Aiton (1810) which is *T. flabellifolia*. Foster (1936) renamed the species *T. rubrolucens*, being unaware that Klatt had described Drège's collection of the same species (Drège 4549) in B, as *Tritonixia disticha*. This species and *T. rubrolucens* are now treated as conspecific, as a wide range of intermediates which connect the two taxa occurs.

KEY TO THE SUBSPECIES

- Outer bracts acute or acuminate, or obtuse and apiculate, usually not 3-toothed, the lower ones on the spike often elongating after flowering a. subsp. **disticha**
 Outer bracts 3-toothed, the middle tooth sometimes reduced, or irregularly toothed, or the lower ones sometimes acute, not elongating after flowering b. subsp. **rubrolucens**

a. subsp. *disticha*

Tritonixia disticha Klatt in Abh. naturf. Ges. Halle **15**: 356 (1882). Type: South Africa, Omsamwubo, Höhe am Fluss, *Drège* 4549 (B, holo-; P, S. iso-). See below.

Tritonia disticha (Klatt) Bak. Handb. Irid. 193 (1892) & in Fl. Cap. **6**: 123 (1896); Klatt in Dur. & Schinz, Consp. Fl. Afr. **5**: 205 (1895).

T. coccinea L. Bol. in Ann. Bol. Herb. **4**: 27 (1925); non Eckl. Top. Verz. 29 (1827). Type: Cape, Pondoland, Port St Johns, *McNair s.n.* NBG 89/23 (BOL, holo-).

Bracts up to 20 mm long; *outer* as described in key. *Flowers* (20–)30–35 mm long, bright red or pink. *Perianth tube* subequal to or slightly longer than the segments. *Style* 14–20 mm long.

NATAL–TRANSKEI—3029 (Kokstad): Clydesdale (-BD), *Schlechter* 6620 (B, L, Z); Ingeli slopes (-DA), *Strey* 6378 (NH).

NATAL—3030 (Port Shepstone): Near Highflats (-AC), *Grant* 3568 (MO); Dumisa am Ifafas (-AD), *Rudatis* 228 (S); Melisa, Port Shepstone & Margate (-CB-D), *Hafström* & *Acocks* 333 (S); Port Shepstone (-CB), *Sidey* 3235 (S); Marburg, *Thode* 5597 (STE); Izotsha Falls, *Prosser* 1418 (K); Paddock (-CC), *Strey* 6136 (NH); Mgongongo (-CD), *Strey* 9451 (NH).

TRANSKEI—3129 (Port St Johns): Omsamwubo, Höhe am Fluss (-AD/-DA), *Drège* 4549 (P, S); Port St Johns (-DA), *Galpin* 3443 (BOL), *McNair* NBG 89/23 (BOL), *Moss* 4317 (BM), *Schonland* 4094 (GRA); Lusikisiki (-BC), *Eglin* NBG 2269/35 (BOL); Mt. Thesiger, (-CB), *Hilliard* 1072 (NU).

—3130 (Port Edward): Port Edward, southern side (-AA), *Bayliss* 2516 (GRA, B, G), *Strey* 4506 (NH, PRE); Umtamvuna River, *Thode* 5099 (STE); 1 mile from Umtamvuna River bridge, *Codd* 10702 (PRE).

Without precise locality: *Drège* 4549 (B); Pondoland, *Bachman* 362 (BM); Wild coast, Transkei, *Van der Riet* NBG 30/63 (STE).

Type: No precise locality is indicated on the holotype sheet, *Drège* 4549 in B. On the isotype sheets in S and P, however, the locality is given as Omsamwubo. This is the river with its mouth at Port St Johns in the Transkei.

This subspecies may be regarded as a low altitude form of the species, ranging from Port St Johns more or less to Margate in Natal, over a distance of some 120 kilometres. Several collections connect the two subspecies and some cannot be correctly placed, e.g. Hb Moss 16034 in BM and K, from Lusikisiki. See also under subspecies *rubrolucens*.

Klatt (1882), followed by Baker (1896), incorrectly described the anthers as being twice as long as the filaments and the spike as distichous (whence the name). As in other species of *Tritonia*, the spike is at first, before the opening of the flowers, distichous, but later becomes subsecund. Baker also incorrectly described the perianth segments as being twice as long as the

tube and used this character in his key to distinguish *T. disticha* from other species such as *T. lineata*.

b. subsp. **rubrolucens** (Foster) De Vos, stat. nov.

Tritonia rubrolucens Fost. in Contr. Gray Herb. Harv. N.S. **114**: 146 (1936), nom. nov. pro *T. rosea* Klatt, nom. illeg. Type as for *T. rosea*.

T. securigera Ker-Gawl. sensu Eckl. Top. Verz. 29 (1827); non (Ait.) Ker-Gawl. (1805).

T. rosea Klatt in Linnaea **32**: 760 (1863) & in Dur. & Schinz, Conspl. Fl. Afr. **5**: 207 (1895); Bak. Handb. Irid. 194 (1892) & in Curtis's bot. Mag. **119** t. 7280 (1893) & in Fl. Cap. **6**: 126 (1896); hom. illeg., non (Jacq.) Ait. 1810 (= *T. flabellifolia* (Delaroché) Lewis). Type: Cape, Katberg, über den Wäldern, Ecklon & Zeyher Irid. 98 (S, lecto-; SAM partly, G). See below.

Montbretia rosea (Klatt) Bak. in J. Linn. Soc. **16**: 169 (1877), non Voigt 1845 (= *T. flabellifolia*).

Tritonixia rosea (Klatt) Klatt in Abh. naturf. Ges. Halle **15**: 356 (1882).

Icones: Curtis's bot. Mag. **119** t. 7280; Batten & Bokelmann Pl. 31/9; Pearse p. 83 Fig. 2.

Bracts up to 15 mm long; *outer* as described in the key. *Flowers* 25–35 mm long, bright red, orange-red or bright pink, sometimes with dark veining. *Perianth tube* subequal to or slightly longer or shorter than the segments. *Style* 18–22 mm long.

Distribution: as indicated for the species.

TRANSVAAL—2730 (Vryheid): South Hill, Wakkerstroom (-AC), *Galpin* 9872 (PRE, K); Oshoek, Wakkerstroom (-AD), *Devenish* 416 (NH, PRE), *Mauve* 4534 (PRE); Kastrolnek, *Van Dam* 28 (PRE).

ORANGE FREE STATE—NATAL—2829 (Harrismith): Van Reenen (-AD), *Wood* 9521 (NH), *Thode* 3915 (STE); Harrismith, Manyenyzaberg, *Jacobsz* 514 (PRE); Oliviershoek, Natal (-CA), *Thode* 9218 (STE); Cathedral Peak area (-CC), *Schelte* 116 (NU), *Robinson* 56 (NU).

NATAL—2830 (Dundee): 51 km S of Nqutu on road to Kranskop (-DB), *Davidse* 6886 (S).

—2831 (Nkandla): Ngoye (-DC), *Huntley* 720 (NU).

—2929 (Underberg): Giant's Castle Game Reserve (-AD), *Trauseld* 584 (NU); Vergelegen Nature Reserve (-CB), *Hilliard & Burtt* 11185 (NU).

—2930 (Pietermaritzburg): Howick (-AC), *Medley-Wood* 9358 (BOL, PRE); Mt Gilboa (-AD), *Hilliard & Burtt* 11867 (NU); Ahrens (-BB), *Fisher* 965 (NU, NH); Zwartkop (-CB), *M. Wood* 10240 (NH); Richmond (-CD), *Saunders s.n.* (K); Inanda (-DB), *M. Wood* 384 (BM), 784 (NH), *Johnson* 1410 (NH); Bothas (-DC), *M. Wood* 12390 (PRE); Kloof (-DD), *Lawson* 680 (NU), *Dohse e.a.* 32 (NH); Hillcrest, *Coleman* 298 (NH).

—3029 (Kokstad): Insiswa (-CD), *Schlechter* 6471 (C, S, Z); Weza-Ngeli slopes (-DA), *Strey* 6378 (NU, PRE).

—3030 (Port Shepstone): Dumisa (-AD), *Huntley* 153 (NU); 10 mls inland from

Scottburg (-BC), *Poynton* 31 (NU); Oribi Flats (-CA), *Rump s.n.* (NU); Mgongogo (-CD), *Strey* 9451 (NH); Skyline, Uvongo, *Nicholson* NH 67241.

—3130 (Port Edward): Port Edward (-AA), *Huntley* 722 (NU).

TRANSKEI—3128 (Umtata): Baziya (-CB), *Baur* 431 (BOL, GRA, NBG, K).

—3129 (Port St Johns): Fraser Falls (-BC), *Leighton* 2999 (BOL); Umkweni (-BD), *Tyson* 2623 (BOL, NBG).

—3228 (Butterworth): Kentani Valley (-CB), *Pegler* 266 (BOL).

SWAZILAND—2631 (Mbabane): Hlatikulu (-CD), *Stewart* 57 (K), 2584 (NBG).

CAPE—3226 (Fort Beaufort): 13.12, i.e. Winterberg zw. Tarka u. Katberg (-AD), *Ecklon & Zeyher Irid* 98 (SAM partly, G), *Ecklon & Zeyher* 13.12 (L, C); Winterberg, *Zeyher s.n.* (K); Katberg near Black Bridge (-BC), *Dyer* 2317 (GRA); Katberg, über den Wäldern, *Ecklon & Zeyher Irid* 98 (S); Katberg, *Galpin* 1704 (GRA, PRE, K), *Harvey s.n.* (K); Katberg Pass, *Adams* 194 (NU); Hogsback, Alice (-DB), *Barker* 39 (BOL); Gaikaskop, Hogsback, *Moss* 15010 (BM), *Young* 988 (K).

—3227 (Stutterheim): Evelyn Valley, *Leighton* 2719 (BOL, GRA, PRE); Summit of mountain above Dohne (-CB), *Flanagan* 2306 (BOL, NBG); Cata Forest Res., Keiskammahoek (-CA), *Strey* 3326 (PRE).

—3325 (Port Elizabeth): Port Elizabeth (-DC), *Kemsley* 1108/174 (GRA); Uitenhage pone Zwartkopsrivier, *Pappe* 239 (SAM, K).

—3326 (Grahamstown): 35 km voor Fort Beaufort vanaf Grahamstad komende (-BA), *Von Teichman* 369 (PRE); 10.10, i.e. Mündung Boesmansrivier (-DA), *Ecklon & Zeyher* 99 (SAM).

Without precise locality: *Drège s.n.* sub *T. rosea* (C); sub *T. securigera* (L); British Kaffraria, *Cooper* 1807 (K); Orange Free State, *Cooper* 3201 (PRE, K); Said to be from Riversdale, *Bayliss* 2421 (G) (cultivated? wrong label?).

Type: Klatt (1863) cited two syntypes: "Ex horto Hesse, leg. *Bergius*, leg. *Krebs*; leg. *Ecklon & Zeyher, Irid* 98. Herb. Reg. Berol". An answer from B to my enquiry stated that these syntypes are no longer there. The only isotypes found are *Ecklon & Zeyher Irid* 98 in SAM, G and S. Those in G and S are the same species (in G from region 13.12, i.e. Winterberg zwischen Tarka und Katberg, and in S from 12.3, i.e. Katberg über den Wäldern). The isotype in SAM comprises two species: two very poor specimens are similar to those in G and S, whereas the other may be *T. lineata*. As the specimens in SAM are so poor, *Ecklon & Zeyher Irid* 98 in S is chosen as lectotype.

This subspecies is very closely related to, and more or less sympatric with *T. lineata*, differing in its later flowering period (summer), in flower colouring and a less pronounced veining on the perianth, and often in a slightly longer perianth tube. Flower colouring varies from pink to bright red or orangy-red. *Baur* 431 in BOL from Baziya in the Transkei has pinkish flowers. *Schelte* 5069 in BOL, from near Port Edward, has "yellow or light red" flowers. Whether this collection constitutes an unusual colour form or hybrids between *T. lineata* and subspecies *rubrolucens*, is uncertain. Its flowering period is that of subspecies *rubrolucens*.

The outer bracts of this subspecies vary. In some collections, e.g. *Moss 15010* in BM, from Gaika's Kop near Alice, the outer bracts of the lowermost flowers of the spike are acute or acuminate and approximate bracts of subspecies *disticha*.

5. Section MONTBRETIA

Sect. *Montbretia* (DC.) Pax in Nat. Pfl. Fam. **2** (5): 155 (1888) in part, excl. *T. rosea*; Diels, *ibid.* ed. 2, **15a**: 491 (1931).

Montbretia DC. in Bull. Sci. Soc. Philom. **3**: 151 (1803); Reichenb. Consp. Regni Veg. **1**: 60 (1828); Klatt in Linnaea **32**: 752 (1863) & in Abh. naturf. Ges. Halle **15**: 359 (1882); Bak. in J. Linn. Soc. **16**: 167 (1877) in part, excl. all spp. except *M. securigera*, *M. laxifolia*, *M. strictifolia*; Stapf in Curtis's bot. Mag. **150** sub t. 9038 (1924).

Tritonia subgenus *Montbretia* (DC.) Bak. Handb. Irid. 190 (1892) & in Fl. Cap. **6**: 199 (1896).

Type species: *T. securigera* (Ait.) Ker-Gawl.

Leaves lanceolate to linear, rarely with undulate margins, rarely slightly succulent. *Inflorescence* a simple or few-branched spike or rarely reduced to a few terminal stalked flowers (*T. florentiae*). *Flowers* zygomorphic, somewhat 2-lipped or sometimes funnel-shaped or rarely almost salver-shaped, red to orange, salmon or yellow, sometimes pink or cream. *Perianth tube* funnel-shaped or tubular, slightly shorter to up to four times as long as the segments; *segments* oblong or oblanceolate, often subequal in length, the posticous segment usually widest, often concave and erect, the three anticus segments, or rarely only the median anticus segment, with a large yellow callus in or near the throat. *Stamens* and *style* curved towards or against the posticous segment; *anthers* usually contiguous, facing the anticus side of the flower.

Distribution: widespread in the Transvaal, southern and eastern Cape Province including the Transkei, and Great Karoo; also in Namaqualand as well as in Mozambique (*T. moggii*), Malawi, Zambia and Tanzania (*T. laxifolia*); excluded from the south western Cape and Natal (Figs 21, 22).

The essential characters of this section are the presence of a large yellow callus on each of the anticus perianth segments, or rarely on the median segment only, and a decided zygomorphy with the posticous perianth segment often widest and concave, thus protecting the stamens and stigmas.

The presence of calli in two species, at that time still under *Gladiolus*, was the reason that A.P. De Candolle (1803) established a new genus, *Montbretia* (the name to commemorate Coquebert-Montbret the younger). This genus was at first recognised by Baker (1877) and Klatt (1863, 1882);

but later, after Bentham had assigned it to the synonymy of *Tritonia* in Bentham and Hooker's *Genera* (1883), Baker (1892, 1896) and Klatt (1895) regarded it as a section or subgenus of *Tritonia*. In the twentieth century Stapf (1924) and Sealy (1939–40) proposed that *Montbretia* be re-established as genus. Phillips (1951) on the other hand, as well as Goldblatt (1976), did not agree with this, and during the present investigation numerous intermediates with small calli or ridges on the anticous perianth segments were found amongst other sections of *Tritonia*; therefore *Montbretia* is here also included with *Tritonia* as a section.

The calli which are often situated on small yellow, red-margined blotches, vary in shape in different species (De Vos, 1982b), and were it not that they are often not readily visible in herbarium material, a better use could be made of this character to distinguish certain species. The only function that can possibly be attributed to the calli is that they narrow the throat of the perianth, thus ensuring that pollinating insects will brush with their backs against the anthers and stigmas. There is no evidence that the calli are nectaries. These are in the septa in the top of the ovary.

Several species, such as *T. watermeyerii*, *T. securigera*, *T. chrysantha*, from the southern and eastern limits of the winter rainfall region, as well as two species from the northern limits of this region (Richtersveld in Namaqualand) are winter rainfall species, sprouting in autumn and flowering in spring and early summer. Another two species, namely *T. florentiae* and *T. karooica*, from the Great Karoo, have retained their winter growing habit and also flower in spring. The remaining five species are from the summer rainfall regions of the eastern Cape and Transvaal, and countries farther north. They sprout in spring or summer. Of these *T. nelsonii*, *T. atrorubens* and *T. drakensbergensis* flower in summer, *T. moggii* from Mozambique in autumn or winter, and *T. laxifolia* in autumn. The last named species has a disjunctive distribution: in the eastern Cape Province and in Central Africa, with apparently a wide interval between these areas.

This section can be subdivided into several groups or subsections. Most of the species are very closely related and have almost similar flowers: somewhat two-lipped with a large posticous perianth segment against which the stamens and style are curved, and large anticous calli. Nine species can be placed in this group, e.g. *T. securigera*, *T. laxifolia*, *T. nelsonii*, *T. watermeyerii*, etc. They are from the southern and eastern Cape, Transvaal and farther north. The two species from the Richtersveld, namely *T. marlothii* and *T. delpierreii*, have somewhat salver-shaped flowers and slightly succulent leaves and form a separate group. The two species from the Great Karoo are very different from each other: *T. florentiae* has an unusual inflorescence; and *T. karooica* has funnel-shaped flowers. Each could be assigned to separate subsections.

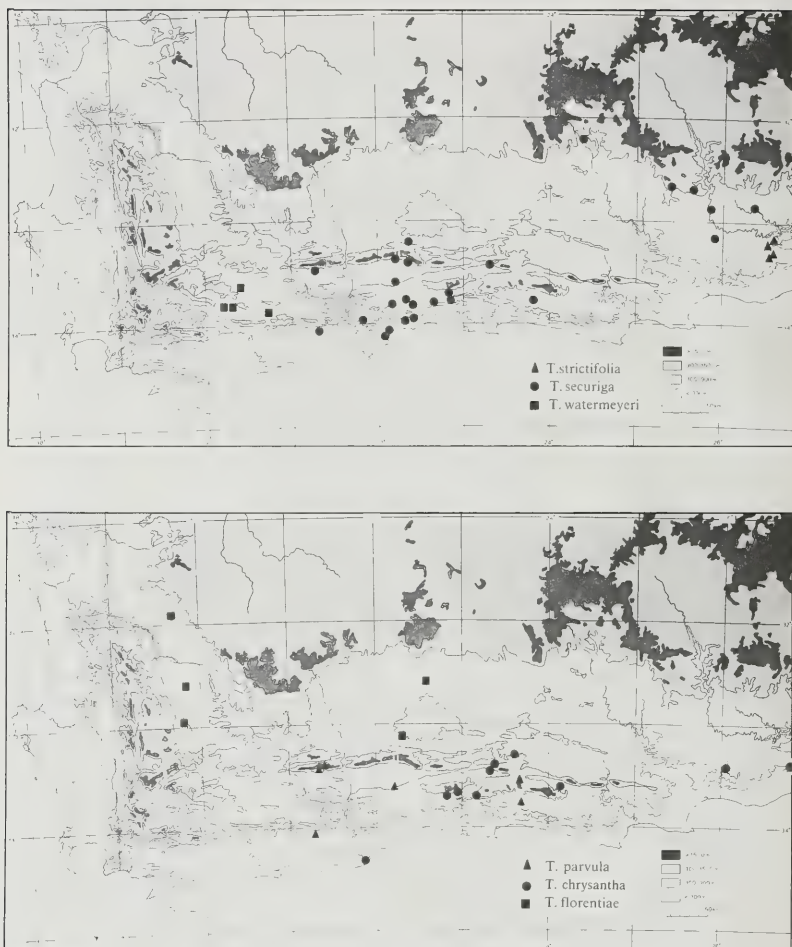


FIG. 21

Geographical distribution of *Tritonia*, section *Montbretia*: *T. chrysantha*, *T. florentiae*, *T. parvula*, *T. securigera*, *T. strictifolia*, *T. watermeyeri*.

Formal subsections are, however, not described, as *T. atrorubens* cannot be placed, on account of somewhat inadequate herbarium material.

Section *Montbretia* is not the *Montbretia* of horticulturalists which consists of species of *Crocsmia* and (or) *Crocsmia* hybrids.

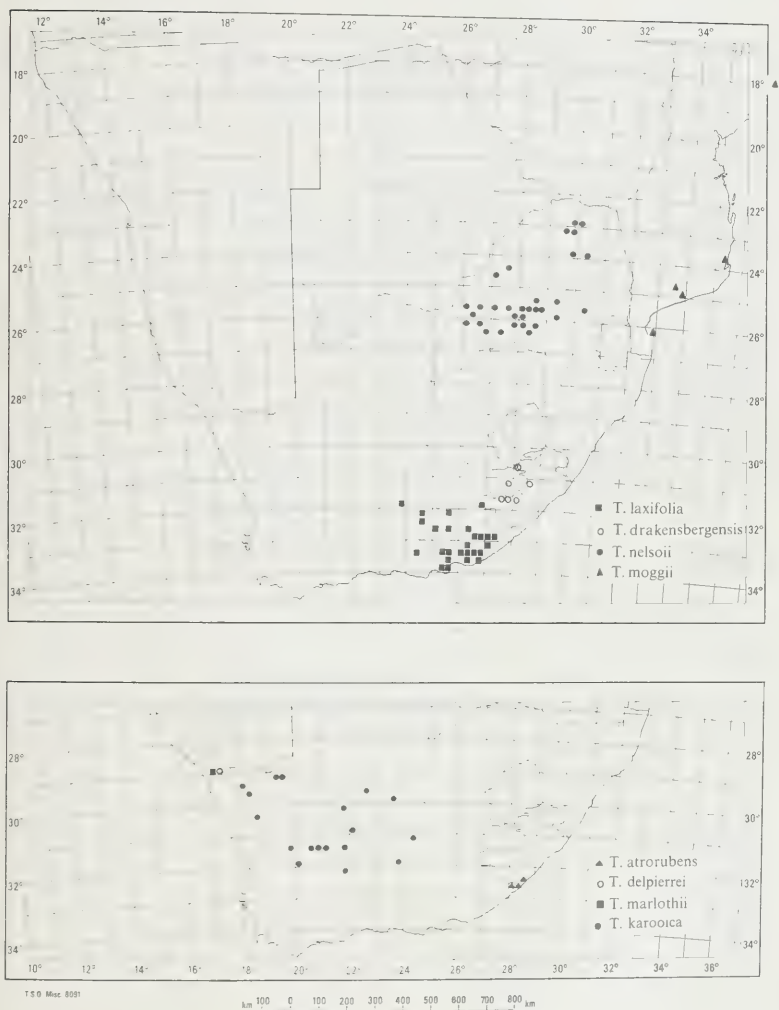


FIG. 22
Geographical distribution of *Tritonia*, section *Montbretia*: *T. atrorubens*, *T. delpierrei*,
T. drakensbergensis, *T. karooica*, *T. laxifolia*, *T. marlothii*, *T. moggii*, *T. nelsonii*.

15. *Tritonia securigera* (Ait.) Ker-Gawl. in Kon. & Sims, Ann. Bot. **1**: 228 (1805); Bak. Handb. Irid. 196 (1892) & in Fl. Cap. **6**: 128 (1896); Klatt in Dur. & Schinz, Consp. Fl. Afr. **5**: 207 (1895).

Gladiolus securiger Ait. Hort. Kew. **1**: 65 (1789); Curtis's bot. Mag. **11** t. 383 (1797). Type: ex Hort. Chelsea, 1778, *s. loc.*, *s. coll.* (BM, lecto-). See below.

Montbretia securigera (Ait.) DC. in Bull. Soc. Philom. **3**: 151 (1803) & in Red. Lil. t. 53 (1804); Klatt in Linnaea **32**: 752 (1863) & in Abh. naturf. Ges. Halle **15**: 359 (1882); Bak. in J. Linn. Soc. **16**: 169 (1877).

Ixia gladiolaris Lam. Encycl. **3**: 341 (1789). Type: Hb. Lam. (P).

I. squalida Thunb. in Hoffm. Phyt. Blätt. **4** (1803) & Fl. Cap. **1**: 244 (1811) hom. illeg., non Ait. Type: HB. Thunberg 996 (UPS).

I. flabellularis Vahl, Enum. Pl. **2**: 67 (1805). Type: Cap. b. Spei, ex herb. Royeni (C, holo-).

I. thunbergii Roem. & Schult. Syst. Veg. **1**: 391 (1817), nom. nov. pro *I. squalida* Thunb. Type as for *I. squalida* Thunb.

Tritonia flava (Ait.) Ker-Gawl. sensu Ker-Gawl. in Bot. Reg. **9** t. 747 (1823); Bak in Fl. Cap. **6**: 128 (1896). (Basionym *Gladiolus flavus* Ait. = *Tritonia* sp. indet.—see SPECIES INSUFFICIENTLY KNOWN p. 412)

Icones: Curtis's bot. Mag. **11** t. 383; Red. Lil. t. 53; an unpublished figure by M. Page in BOL; this work Fig. 23/2.

Type: The type material in BM comprises two sheets, one with two plants, e Hort. Chelsea 1778, without collector or locality, and the other with a single flowering scape, from Cap. b. Spei, without collector or date. These are probably plants or descendants of plants, brought back from the Cape by Masson. The first is chosen as lectotype.

Plants (100–)150–300(–350) mm long. *Corm* subglobose, 10–20 mm diam.; tunic fibres fine or sometimes rather strong, matted, reticulate in the upper part, almost parallel in the lower. *Scape* (100–)150–300(–450) mm long, erect or suberect, simple or with one branch, sometimes with a collar of old leaf bases around the base. *Leaves* 4–7, suberect or rarely spreading, lanceolate or lanceolate-linear, (70–)100–200(–270) × (4–)6–10(–12) mm, acute or acuminate, obscurely veined, with a slightly stronger middle vein, not reaching the spike or sometimes as long as the spike; cauline leaves 1–2,

FIG. 23

Tritonia laxifolia (De Vos 2443): 1a, plant and front view of flower; 1b, dehiscing capsule.

Tritonia securigera (De Vos 2417): 2a, plant and front view of a flower; 2b, outer (left) and inner (right) bract; 2c, flower half in a median longitudinal cut; 2d, dehiscing capsule.



up to ca. 60 mm long. *Spike* erect, rather lax, almost secund, with 5–15 flowers. *Bracts* membranous, papery, ovate, 7–10(–12) mm long, pale with dark veins, brownish towards the top; *outer* 3- or 5-toothed or irregularly toothed, veined; *inner* 2-dentate, 2-veined, sometimes slightly shorter than the outer. *Flowers* suberect and slightly spreading, (28–)30–35(–45) mm long, reddish-orange or apricot, with a yellow throat, or almost wholly yellow (RHS 28B, C, 31B, 26B, 23C, 19B, 21D), with the upper lobe sometimes pale yellow inside. *Perianth tube* tubular in the lower half, funnel-shaped in the upper, (10–)12–15(–20) mm long, slightly curved; *segments* unequal, obtuse, 12–20 mm long, the posticous segment obovate, often slightly concave, (8–)12–15 mm wide; other segments oblong to oblanceolate, spreading, upper laterals 7–11 mm wide, anticus segments 5–8 mm wide, each with a high, and usually wide, callus in the yellow red-margined throat. *Stamens* curved towards the posticous segment; *filaments* 9–12(–15) mm; *anthers* contiguous 5–6 mm long, purple or mauve, reaching halfway or sometimes higher up the perianth lobes; pollen mauve. *Style* slightly bent, 17–20(–25) mm long; *stigmatic branches* 4–5 mm long, often overtopping the anthers. *Capsules* ellipsoid, 7–10 mm long; *seeds* brown, shiny, angled, reticulate-foveate, 1.5–2 mm diam.

Flowering period: September to early December.

Distribution: in the Little Karoo, Langkloof, eastern Karoo and southern Cape coastal districts of Mossel Bay, George and Humansdorp (Fig. 21).

CAPE—3224 (Graaff-Reinet): Kamdebo (-AB), *Dunn* BOL 31758.

—3225 (Somerset East): Prope Middleton (-DD), *Rogers* BOL 12945.

—3226 (Fort Beaufort): 17 km E of Adelaide (-CD), *De Vos* 2573 (STE).

—3321 (Ladismith): 5–10 mls W of Ladismith (-AD), *Rycroft* 3029 (NBG); Foothills of Langeberg N of Herbertsdale (-DD), *Goldblatt* 4155 (MO).

—3322 (Oudtshoorn): Kleine Poort, *Tyson* 3071 (PRE, SAM, K); Eikerkraal betw. Klaarstroom & Prince Albert (-AB), *Leipoldt* BOL 31763; Foot of Swartberg Pass on road to Oudtshoorn (-AC), *Goldblatt* 2958 (MO); Between Cango and DeRust (-AD), *Thorne* SAM 53367; Oudtshoorn (-CA), *Yeoman s.n.*, 17/5/25 (NBG), *Deas* SAM 11639; Ruiterbos (-CC), *Barker* 7677 (NBG); Hills near Zebra (-CD), *Taylor* 850 (NBG); Camfer, *De Vos* 2416 (STE); George, *Marloth* 2455 (PRE); Near George, *Burchell* 6090 (K), *Compton* 13214 (NBG), *Goldblatt* BOL 31762; Near Blanco, *Middlemost* 1785 (BOL, NBG, STE, S); Between Grootbraak River & George, *Fourcade* 4074 (STE); George forest, *Barker* 6858 (NBG); Eseljagsrivier (-DC), *De Vos* 2417 (STE); Eseljagspoort, S end, *Oliver* 3584 (PRE); Betw. Eseljags & Molenrivier, *De Vos* 2418 (STE); 56 km E of Oudtshoorn, *Goldblatt* 2855 (MO); Oudtshoorn to Avontuur, *Goldblatt* 450 (BOL).

—3323 (Willowmore): Modderfontein, distr. Willowmore, *Andreae* 1042 (PRE); Zuurborg at Georgida (-AD), *Fourcade* 4629 (STE); Banks of Wagenboomsrivier near Joubertina (-DD), *Fourcade* 2331 (K).

—3325 (Port Elizabeth): Kommadagga (-BB), *Bayliss* 6085 (PRE, MO, S).

—3421 (Riversdale): Riversdale (-AB), *Bayliss* 2421 (G, not in SAM).

—3422 (Mossel Bay): Brak River (-AA), *Hops* 250 (BOL); Great Brak, slopes above station, *Lewis* 5607 (NBG, STE); Near Mossel Bay, *Bowie* 1 (BM).

Without precise locality: *Thunberg* 996 (UPS); *Ecklon* ex Mont. tab. pr. b. Sp (L) (probably a wrong locality label); *Herb. Royeni* (C).

This is one of the first of the callus-bearing species of *Tritonia* found in South Africa, for which Aiton (1789) coined the appropriate epithet of *securigera* (axe-bearing).

The species is closely related to *T. laxifolia* from which it can best be distinguished by its different flowering period. Other points of difference, often not evident in herbarium material, are the yellow throat of the perianth, usually broader and less high calli, shorter stamens which usually do not reach more than halfway up the perianth segments, and shorter capsules. The two species occupy neighbouring areas in the south eastern Cape Province; towards the eastern extremity of its range *T. securigera* often shows calli that are higher than usual, approximating those of *T. laxifolia*.

T. securigera is also closely related to *T. chrysantha* and *T. parvula*. It differs from the latter in its usually wider, firmer leaves, somewhat larger flowers with slightly longer perianth tube, stamens and style, and with the posticous perianth segment not, or only slightly, concave. It differs from *T. chrysantha* in its shorter perianth tube and usually in flower colouring which varies from a deep reddish-orange or apricot to salmon or various shades of yellow. The yellow-flowered form of *T. securigera* can be distinguished from *T. chrysantha* only by its shorter perianth tube.

The figure identified as *T. flava* in *Botanical Register* 9 t. 747 probably represents the yellow-flowered variation of *T. securigera*. This figure, being that of a plant from a later introduction into Britain, does not correspond with the holotype of *T. flava* (Ait.) Ker-Gawler in BM which, on account of its poor condition, cannot be connected with any species of *Tritonia*. See also under SPECIES INSUFFICIENTLY KNOWN.

A wide variation in size occurs in *T. securigera*. Some collections, e.g. *Fourcade* 4094 and 5054 from the Great Brak and George vicinity, consist of small plants 100–150 mm long with short, spreading leaves and few flowers; whereas specimens from the eastern Karoo, widespread between Fort Beaufort and Pearston, e.g. *De Vos* 2573, as well as *Bayliss* 6085 from Komma-dagga, are up to 350 mm long with bracts to 15 mm and flowers 30–40 mm, with a perianth tube of 15–20 mm, and long leaves with a slightly stronger vein near each edge. As smaller plants were observed amongst the large plants, the latter have not now been described as a distinct variety.

16. *Tritonia chrysantha* Fourcade in Trans. Roy. Soc. S. Afr. 21: 77 (1932). Type: Cape, Uniondale, hills S of Georgida, *Fourcade* 4394 (BOL, holo.; STE, K).

Fig. 24.

Plants (100–)200–300(–500) mm long. *Corm* subglobose to ovoid, 10–20 mm diam.; tunic fibres strong, reticulate, almost parallel and plate-like towards the base. *Scape* (100–)200–300(–500) mm long, erect or slightly bent, simple or with 1–2 branches, often with dried leaf bases 40–100 mm long at the base. *Leaves* 4–7, lanceolate, acute, 50–100(–200) \times (2–)5–10 mm, suberect or sometimes spreading, usually not reaching the base of the spike; cauline leaves 1–2, subulate. *Spike* distichous, lax, sometimes with 1–2 branches, with 2–8 flowers. *Bracts* membranous, 6–12 mm long; *outer* 3- or 2-toothed, with obtuse or acute teeth, with reddish-brown veins; *inner* 2-toothed, acute or acuminate, 2-veined, sometimes slightly shorter than the outer. *Flowers* (30–)35–40(–48) mm long, bright yellow (RHS 8B). *Perianth*



FIG. 24

Tritonia chrysantha (De Vos 2419): a, plant and front view of flower; b, outer (left) and inner (right) bract; c, flower half in a median cut; d, capsules.

tube (18-)20-28 mm long, tubular, widening gradually to 6-7 mm diam. in the upper quarter; segments ovate-spathulate, obtuse, (8-)10-15 mm long, the posticous segment 9-12 mm wide, often slightly hooded, the others 5-8 mm wide, spreading, the three lower ones with a large yellow callus up to 5 × 3 mm. Stamens curved towards the posticous segment; filaments 7-10 mm; anthers 4-6 mm long, violet or yellow, reaching halfway or higher up the perianth lobes. Style 20-30(-35) mm; stigmatic branches 3-5 mm long, sometimes overtopping the anthers. Capsules ca. 6 mm long; seeds shiny brown, 2 mm diam. Chromosome number $2n = 22$.

Flowering period: late August to October.

Distribution: chiefly in the Little Karoo and southern and south eastern Great Karoo (Fig. 21).

CAPE—3225 (Somerset East): Zuurberg mts. near Somerset East, Bayliss 7132 (MO).

—3322 (Oudtshoorn): Slopes east of Laudina (-DB), Oliver 3588 (STE, PRE); Between Buffelsdrif & Bassau (-DB), De Vos 2419 (STE).

—3323 (Willowmore): Roodeklip SW of Anthoniesberg (-AD), Taylor 868 (NBG); S of Georgida, Fourcade 4394 (STE, BOL, K); Farm Vaalwater SE of Willowmore (-BC), Thompson 2008 (STE, K); Near Uniondale (-CA), Zinn SAM 65867, Yates PRE 36625; Hoogtes Pass, Potjiesrivier, Acocks 21593 (PRE).

—3324 (Steytlerville): Baviaanskloof (-CA), Bayliss 4954 (NBG, MO).

—3326 (Grahamstown): Near Alicedale (-AC), Bayliss 8047 (STE, MO), Bayliss 6811 (MO); Trappes Valley (-BD), Bayliss 2404 (MO).

—3421 (Riversdale): The Fisheries (-BD), Acocks 21565 (NBG, PRE).

This species is distinguished by bright yellow flowers with a narrow perianth tube about twice the length of the segments and a large yellow callus often on a small pinkish-red blotch, on each of the anticus perianth segments. It is closely related to *T. securigera* and can be confused with the yellow-flowered form of this species, from which it differs in its longer perianth tube.

17. *Tritonia parvula* N.E.Br. in Kew Bull. 1931: 452. Type: Cape, near Oudtshoorn, Muir 4724 (K, holo-).

Plants (80-)150-250(-300) mm long. Corm 5-10 mm diam., ovoid; tunic fibres strong, reticulate in the upper half, almost parallel in the lower. Scape (60-)120-200(-250) mm, slender, curved or flexuose, rarely branched. Leaves 4-7, linear, acuminate, somewhat flaccid, suberect or spreading, sometimes recurved, 80-300 × (0.5-)1-2(-4) mm, often longer than the scape, with a slender middle vein. Spike lax, often flexuose, with (1-)2-6 flowers, rarely with one branch. Bracts membranous, 5-9 mm long, pale brown, with darker veins; outer minutely 3-toothed, darker brown upwards;

inner minutely bidentate. *Flowers* zygomorphic, (18-)22-30 mm long, red-dish-orange to salmon, with a yellow throat. *Perianth tube* tubular in the lower half, funnel-shaped above, 6-10(-13) mm long, widened to ca. 6 mm diam. at the throat; *segments* oblanceolate, obtuse, 9-12(-15) mm long, the posticous segment concave and hooded, often paler inside 6-10(-12) mm wide, the other 4-6 mm long, with a high yellow callus on each anticous segment. *Stamens* curved towards the posticous segment; *filaments* 6-10 mm; *anthers* 4-5 mm long, curved, often violet, reaching below to above the middle of the perianth segments. *Style* (10-)15-20 mm; *stigmatic branches* 2.5-3 mm long, reaching or overtopping the anthers. *Capsules* shortly ellipsoid, ca. 6 mm long.

Flowering period: late September to October (to December).

Distribution: southern districts of the Cape Province from Riversdale to Willowmore Fig. 21).

CAPE—3321 (Ladismith): Seweweekspoort (-AD), *Compton* 7473 (NBG); *Wurts* 1607 (NBG); Klein Swartberg near Hoekoe, *Wurts* 1476 (NBG).

—3322 (Oudtshoorn): Oudtshoorn (-CA), *Barker* 7604 (NBG), SAM 53185, BOL 31776, *Muir* 4724 (K).

—3322 Willowmore): Boskloof, Baviaanskloof (-DA), *Hugo* 1444 (STE); 2.2 mls from Louterwater to Oudtshoorn (-DC), *Marsh* 1406 (PRE, STE).

—3421 (Riversdale): Rock faces at Glen (-AB), *Muir* BOL 31773.

Without precise locality: Oudtshoorn flower show, SAM 9392 partly.

T. parvula is very closely related to, and largely sympatric with, *T. securigera*. It differs from the latter in its more flaccid appearance, its narrow, flaccid, linear leaves, a somewhat flexuose spike that has slightly smaller flowers with smaller floral parts and with the median posticous perianth segment strongly concave and the calli on the lateral anticous segments sometimes reduced in size. *Hugo's* collection no. 1444 in STE, from Baviaanskloof, seems to connect the two species. Here the spike and flowers approximate those of *T. securigera*, but the leaves are only 2 mm wide. *T. parviflora* might perhaps be regarded as a depauperated variety of *T. securigera*.

18. *Tritonia strictifolia* (Klatt) Benth. ex Klatt in Dur. & Schinz, *Consp. Fl. Afr.* 5: 208 (1895).

Montbretia strictifolia Klatt in *Linnaea* 32: 753 (1863) & in *Abh. naturf. Ges. Halle* 15: 359 (1882); Bak. in *J. Linn. Soc.* 16: 169 (1877). Syntypes: Cape, Albany, auf grasreichen Hügeln bei Grahamstown, *Ecklon & Zeyher* 100 (B, lecto-; SAM, G, S, Z); Uitenhage, Kalkhöhe zw. Zwartkoprivier u. Zondagsrivier, *Ecklon & Zeyher* 260 (B, not seen).

Tritonia laxifolia Benth. ex Bak. var. *strictifolia* (Klatt) Bak. *Handb. Irid.* 195 (1892) & in *Fl. Cap.* 6: 127 (1896).

T. parviflora Bak. in Bull. Herb. Boiss. Ser. 2, 1: 865 (1901). Type: Kapkolonie, Ecklon & Zeyher 100 (Z, holo-; SAM, B, G, S).

Plants 150–200(–270) mm long. Corm 10–20 mm diam.; tunic fibres fine, almost parallel in the lower half, reticulate in the upper. Scape 150–200 (–270) mm long, slightly flexuose towards the top, often with one branch. Leaves 4–7, linear-lanceolate, usually erect, (40–)60–90 × 2–5 mm, acute or acuminate, drying to a light brown, with a prominent vein near the margins and in the middle, not reaching near the spike; cauline leaf one, ca. 15 mm long. Spike rather lax, often slightly flexuose, somewhat distichous, with 3–5 flowers, often with a 1–2-flowered branch. Bracts membranous, brown, 7–10 mm long; outer striate, 3-toothed; inner bidentate, with acuminate teeth. Flowers zygomorphic, (20–)25–35 mm long, rust-orange or pink. Perianth tube 10–15 mm long, funnel-shaped, widened to ca. 8 mm diam. upwards; segments obtuse, 13–18 × 5–10 mm, with the posticous segment widest, anticus segments with a high, narrow, yellow callus on a yellow mark. Stamens curved towards the posticous segment; filaments 7–10 mm; anthers contiguous, ca. 5 mm long, reaching halfway or higher up the perianth segments. Style 17–20 mm; stigmatic branches 3–4 mm long, reaching or overtopping the anthers.

Flowering period: November.

Distribution: south eastern Cape Province, Grahamstown district (Fig. 21).

CAPE—3326 (Grahamstown): Auf grasreichen Hügeln bei Grahamstown (-BC), Ecklon & Zeyher 100 (SAM), Irid. 100 (B, G, S, Z); Between Grahamstown and Botha's Hill, Hutchinson 1586 (BOL. K); Commonage N of Grahamstown, Barker 6940 (STE); Grahamstown flats, Galpin 386 (PRE); 4 mls NE of Grahamstown, Gillett 2517 (BOL, STE).

Without precise locality: Ecklon s.n. sub *T. squalida* (C); Ex hb. Royen sub *Ixia* (*Morphixia*) *capillaris* B stricta (C).

This species comprises small plants with narrow, erect, linear-lanceolate leaves often less than 100 mm in length and usually less than 5 mm wide; and with few, short-tubed flowers resembling those of *T. securigera* and *T. laxifolia*. The leaves have three prominent veins, two of which are near the margins. The calli on the anticus perianth segments are high and narrow as in *T. laxifolia* and the eastern form of *T. securigera*. The two lateral calli are, however, sometimes reduced in size. Variation occurs in flower colouring which was described as red ("miniata") by Klatt (1863); but later collectors noted the colour as rust-orange or pink.

The species is related to *T. laxifolia* and *T. securigera*, differing in its smaller, erect leaves with their strong submarginal veins, and from the for-

mer also in its different flowering period. As the leaves are so distinctly different and the flowering period different from that of *T. laxifolia* with which Baker (1896) associated it as a variety, *T. strictifolia* is once again raised to specific rank.

In habit *T. strictifolia* resembles *T. lineata* var. *parvifolia* and herbarium specimens can be confused, notwithstanding the difference in flower structure. This variety occurs in the districts of Port Elizabeth and Uitenhage which adjoin the Grahamstown district. Klatt's second syntype, *Ecklon & Zeyher 260*, from Kalkhöhe in the Uitenhage district, could not be found during the present investigation. There is some slight possibility that it may be this small variety of *T. lineata*, as its locality, as well as its seeming preference for chalky ground, is that of the latter.

19. ***Tritonia laxifolia*** (Klatt) Benth. ex Bak. Handb. Irid. 195 (1892) & in Fl. Cap. 6: 126 (1896) excl. var. *strictifolia*; Klatt in Dur. & Schinz, Consp. Fl. Afr. 5: 206 (1895); N.E.Br. in J. Linn. Soc. 48: 47 (1928).

Montbretia laxifolia Klatt in Linnaea 32: 754 (1863) & in Abh. naturf. Ges. Halle 15: 359 (1882); Bak. in Trans. Linn. Soc. 29: 155 & t. 101A (1875) & in J. Linn. Soc. 16: 169 (1877); Stapf in Curtis's bot. Mag. 150 t. 9038 (1928) as *M. laxiflora* (sic), excl. syn. *M. strictifolia*. Syntypes: Cape, C.B.S., *Krebs s.n.*; *Drège 3489a* (K, lecto-; SAM, G, L, MO, S); Locality 103, i.e. Uitenhage, Steenbokvlakte, *Ecklon & Zeyher Irid. 105* (B, G, SAM, S, MO).

Ixia fenestrata Jacq. sensu Thunb. in Hoffm. Phyt. Blätt. 4 (1803) & in Fl. Cap. 244 (1811); non Jacq. (1789 & 1809).

Tritonia bakeri Klatt in Dur. & Schinz, Consp. Fl. Afr. 5: 203 (1895); non Klatt (1882). Type: German East Afr. 5° 50' S, 30° E, *Speke & Grant s.n.* (K).

T. clusiana A. Worsley in Gard. Chron. 38: 269 (1905). Type: South Africa, said to have come from the Greytown distr., *Worsley s.n.* (K, holo-).

T. bracteata A. Worsley in Gard. Chron 39: 2 (1906). Type as for *T. clusiana*.

Icons: Curtis's bot. Mag. 150 t. 9039; an unpublished drawing by G. J. Lewis (BOL); Trans. Linn. Soc. 29 t. 101A (incorrect, calli not shown); this work Fig. 23/1.

Plants (150–)200–400(–600) mm long. *Corm* subglobose, 10–15 mm diam.; tunic fibres very fine, reticulate in the upper part, subparallel towards the base, often with small basal cormlets. *Scape* 140–400(–600) mm long, erect or suberect, simple or with 1–2 or rarely more branches. *Leaves* 4–7, lanceolate or linear-lanceolate, acute or acuminate, suberect or sometimes spreading, 100–300(–500) × 5–10(–12) mm, with a strong middle vein and

sometimes a slightly stronger lateral vein near each edge, often reaching the base of the spike; cauline leaves 1–2, shorter and narrower. *Spike* somewhat lax, secund, sometimes 1–2-branched, with 6–12 or more flowers. *Bracts* membranous, reddish-brown, often with fine brown stippling towards the top, with wide, brownish, papery margins, 6–12(–18) mm long; *outer* 3-toothed or rarely 5-toothed or subacute, striate, with a stronger median vein ending in a dark, sometimes reduced and short middle tooth; *inner* bidentate, the teeth with dark brown tips, 2-veined, sometimes slightly shorter than the outer. *Flowers* suberect and slightly spreading, (22–)25–32(–35) mm long, bright salmon-pink to pale brick-red (RHS 33C, 34C, D) the cup and sometimes the posticous perianth segment pale inside. *Perianth tube* narrowly tubular in the lower half, widely funnel-shaped in the upper, slightly curved, 12–16 mm long; *segments* unequal in width, obtuse, (10–)12–15 mm long, median posticous segment obovate to subrotund, 8–12 mm wide, suberect, concave and slightly hooded; other segments elliptical, 5–8 mm wide, the three anticus segments with a narrow, curved, yellow or greenish-yellow, callus 3–5 mm high, on a small yellow, red-margined blotch. *Stamens* curved against the posticous perianth segment; *filaments* 12–15 mm long; *anthers* 4–6 mm long, contiguous, reaching to the upper quarter of the posticous segment, mauve or purple; pollen pale. *Style* 18–20(–22) mm long; *stigmatic branches* 2–4 mm long, reaching the anther tips or just above or below them. *Capsules* ellipsoid and somewhat trigonous, erect, up to 15 mm long; *seeds* brown, finely ribbed, ca. 2 mm diam.

Flowering period: (January to) March to May (to July, Central Africa).

Distribution: eastern Cape Province from Uitenhage to East London and eastern and north eastern parts of the Great Karoo, as well as in the Central African states of Malawi, Zambia and Tanzania (Fig. 22).

CAPE—3126 (Queenstown): Mountain side, Queenstown (-DD), *Galpin* 2036 (GRA, PRE, K); Junction farm, Queenstown, *Galpin* 8187 (PRE).

—3224 (Graaff-Reinet): Along Sunday River N of Monkey Ford (-BA), *Burchell* 2867 (K, L); Prope Graaff-Reinet (-BC), *Bolus* 597 (BOL, K), *Bayliss* 4457 (MO); Ad pedes Spandouw Kop, *Francis* 17 (BOL).

—3225 (Somerset East): Cradock (-BA), *Brincker* TM 20243 (PRE), Bot. Hon. 306 (MO); Pearson (-CA), *Palmer s.n.*, Apr. 1962 (PRE); Ad pedis montis Boschberg (-DA), *MacOwan* 275 (K).

—3226 (Fort Beaufort): Adelaide (-CB), *Van Eden* NBG 1444/31 (BOL); Baddaford farm (-DC), *Killick* 871 (PRE); Near top of Koonop Heights, *Schonland* 3709 (PRE); Alice, Fort Hare (-DD), *Goldblatt* 406 (BOL).

—3227 (Stutterheim): Near Fort Cox (-CC), *Sidey* 616 (S); Kingwilliamstown (-CD), *Godfrey* 57 (GRA).

—3324 (Steytlerville): Near Steytlerville (-AD), *Rousseau* 11 (PRE).

—3325 (Port Elizabeth): Locality 103, i.e. Steenboksvlakte (-AD), *Zeyher* 105 (SAM), *Ecklon & Zeyher Irid* 105 (B, G, S, MO); Coerney (-BC), *Schonland* 3249 (GRA); Enon, *Drege* 3489a (K); In collibus prope Uitenhage (-CD), *Schlechter* 2510

(BOL, GRA, G): Elandsrivier catchment basis, *Scharf 1311* (PRE); Addo (-DA/-B), *Brynard 353* (PRE), *Urton 246* (GRA); In der Kloof, Adow, *Drège 3489a* (SAM); Port Elizabeth (-DC), *Meyer PRE 36611*; 15 mls E of Port Elizabeth, *Lewis 4433* (PRE, SAM); Redhouse, *Paterson 1011* (GRA); Mr. Crew's farm, Coega, *De Vos 2442* (STE), *Dahlstrand 665* (PRE).

—3326 (Grahamstown): Grahamstown district, *Bayliss 1227* (B), *Rogers 27741* (STE); Helpoort (-AB), *Bayliss 5722* (C, MO); Alicedale (-AC), *Cruden 220* (STE); Ca. 15 mls SW of Grahamstown (-AD), *Lewis SAM 65866* (PRE); 11 mls from Grahamstown on Salem road, *Cheadle 734* (PRE); Grahamstown (-BC), *Daly & Sole 67* (PRE), *Rogers 27741* (GRA); Grahamstown flats, *Brüten A60* (GRA); Peddie road 15 mls from Grahamstown (-BD), *Dyer 1382* (GRA, PRE); De Bega valley, Alexandria (-CB), *Galpin 10662* (PRE), *Galpin s.n. BOL 31761*, *Archibald 4118* (PRE); Alexandria, *MacOwan s.n.*, 3/1884 (K), *Theron 259* (PRE); Boesmansrivier valley between Grahamstown and Alexandria, *De Vos 2443* (STE); Bathurst (-DB), *Sidey 3673* (PRE).

—3327 (Peddie): Keiskamma, *Hutton s.n.*, 3/68 (K).

Without precise locality: *Thom. s.n.* (K); *Harvey s.n.* (K).

TANZANIA—Iringa, Sao Hill, *Watermeyer 42* (K); 11 mls SE of Iringa, *Polhill & Paulo 1388* (PRE, B, K, SRGH); Songea distr., *Hay 110* (B, K); Njombe distr., *Leedal 5308* (K); Ufipa distr., *Bullock 2248* (K); Kondoia distr., *Burt 961* (K); German East Africa, *Speke & Grant s.n.* (K).

ZAMBIA—Abercorn distr., Kawimbe, *Richards 8002* (K); Kapatamoyo near Fort Jameson, *Robson 1040* (K, SRGH); Near Lundazi, *Anton-Smith 140* (SRGH).

MALAWI—Mzuzu distr., Vipya Range, *Richards 14458* (K); Mzimba distr., Vipya plateau, *Pawek 8903* (K); 37 mls SW of Mzuzu, *Pawek 8050* (SRGH); Nkhata Bay distr., Vipya mts., *Williamson & Ball 1810* (SRGH); Luwawa, Vipya, *Chapman 1547* (SRGH); Dzalanyama Forest, *Adlard SRGH 135188*; Dedza distr., Ciwan Hill, *Banda 411* (SRGH); Zomba mts., *Whellan 1161* (SRGH); Dedza district, Chongoni Forest Reserve, *Brummit 10152* (K); Mpata mlonde Hill, Dedza distr., *Jackson 2161* (K); Sangono Hill, *Adlard 238A* (K).

Herbarium material of this species from Central East Africa is indistinguishable from the eastern Cape Province material. Baker (1875) also considered this to be the case, as he described the only Central African collection then known, which had been brought back by Speke and Grant's expedition of 1860, as *Montbretia laxifolia* Klatt. He did not indicate the presence of calli either in his quite extensive description or in the accompanying figure. However, the specimen cited, preserved in the Kew herbarium, distinctly shows high calli on the perianth. As Baker had omitted to indicate calli, Klatt thought these Central African plants to be a different species and in 1895 he named it *T. bakeri*, which is a later homonym.

T. laxifolia and the closely related *T. securigera* are a vicarious species pair occupying neighbouring areas in the Cape Province. They resemble each other extensively and are best distinguished in herbaria by their different flowering periods, *T. laxifolia* being the only autumn flowering species of the southern Cape Province. The Cape *T. laxifolia* also differs from *T. securigera* in its slightly smaller flowers showing a cup whitish inside with slender dark lines, higher and narrower, almost peg-like, calli, and anthers reaching

slightly higher up the perianth; also in its longer, ellipsoid, erect capsules and its usually longer, somewhat more flaccid leaves, as well as in its more eastern distribution in the Cape Province.

It differs from *T. nelsonii* of the Transvaal in its usually shorter and wider leaves with less prominent, more widely spaced veins, in its perianth tube which is narrowly tubular in the lower half and in its longer, ellipsoid capsules. Three collections from the Central Region of Malawi in the Kew herbarium, namely *Brummit 10152* and *Jackson 2161*, both from the Dedza district, and *Adlard 238A* from Sangono Hill, have narrower leaves resembling *T. nelsonii* in this feature. The first-mentioned was found on rocky slopes and the second in very shallow soil overlying rocks. These habitats may perhaps have contributed to their narrower leaves.

20. *Tritonia watermeyerii* L. Bol. in Ann. Bol. Herb. 4: 44 (1926). Type: Cape, allegedly Vanrhynsdorp, *Watermeyer BOL 18050* (BOL, holo-).

Montbretia watermeyerii (L.Bol.) Sealy in Curtis's bot. Mag. 174 t. 428 (1963); Pike in Gard. Chron. 152: 335 (1962).

Icones: Curtis's bot. Mag. 174 t. 428; a coloured figure by M. Page in BOL; this work **Fig. 25**.

Plants (100–)200–300 mm long. *Corm* ovoid, 7–15 mm diam.; tunic fibres fine to strong, reticulate. *Scape* (60–)120–300 mm long, erect or somewhat flexuose, with old leaf bases up to 80 mm long around its base. *Leaves* 3–7, linear-lanceolate, acute, 50–125(–150) × 2–8 mm, suberect or spreading, with strongly undulate margins, sometimes spirally twisted, with a slender middle vein. *Spike* simple, distichous, lax, with 2–6 flowers, rarely reduced to one. *Bracts* membranous, ovate, concave, 6–9 mm long, brown and minutely stippled in the upper part, often purplish in the lower; *outer* 3-toothed or irregularly toothed, with purplish veins; *inner* bidentate, 2-veined, with wide, pale, membranous margins. *Flowers* almost 2-lipped, (25–)30–40 mm long, faintly fragrant, burnt orange or pinkish-orange (RHS 31A), the upper perianth segments often pale salmon or buff-coloured inside, the lower segments with a red-margined yellow zone in the throat. *Perianth tube* tubular in the lower 3–7 mm, widened to ca. 7 mm diam. at the top, 10–16 mm long; *segments* unequal, obtuse, median posticous segment obovate, erect, concave, 15–22 × (8–)12–15 mm, lateral posticous segments spreading, oblong, 15–18 × 7–10 mm, anticous segments oblanceolate, deflexed just above the base, 11–14 × 5–9 mm, each with a yellow truncate callus 3–4 mm high. *Stamens* curved against the posticous perianth segment; *filaments* 12–18 mm; *anthers* 4–5 mm long, straight or curved, contiguous, violet or mauve; pollen pale. *Style* 17–25 mm; *stigmatic branches* 3–4 mm, as high as the anthers or just overtopping them. *Capsules* obovoid-

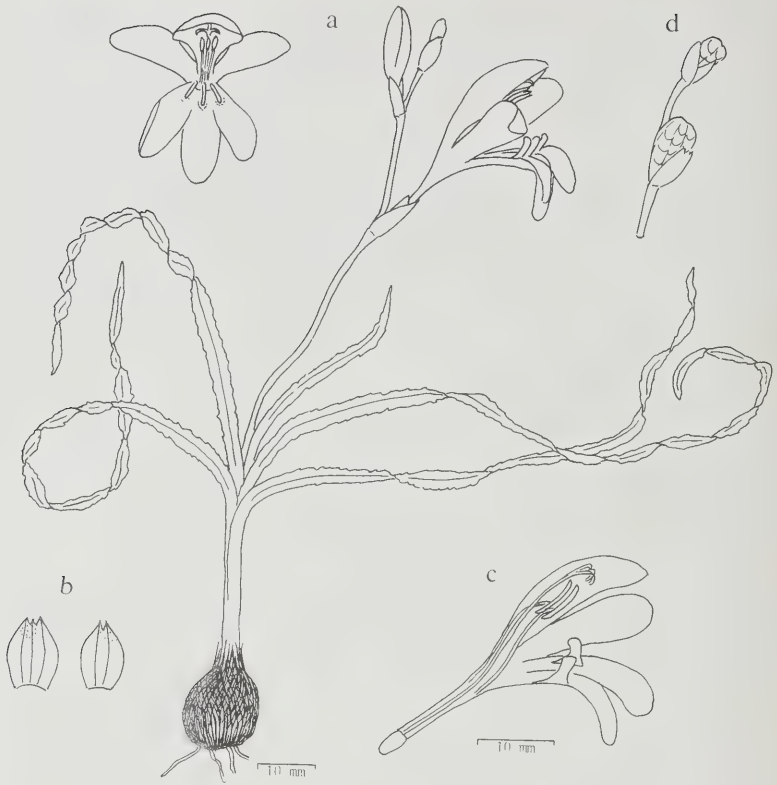


FIG. 25

Tritonia watermeyerii (Malan 112): a, plant and front view of flower; b, outer (left) and inner (right) bract; c, flower half in a median cut; d, capsule.

trigonal, ca. 10 mm long; *seeds* round, brown, minutely reticulate-colliculate, 1,5 mm diam.

Flowering period: August to October.

Distribution: in a small area hardly 60 km in diameter in the Little Karoo east of Montagu, to Barrydale (Fig. 21). The Vanrhynsdorp locality is probably incorrect.

CAPE— 3320 (Montagu): Allemorgens (-CB), *Malan 112* (NBG, STE); 5,5 mls from Montagu towards Ladismith via Kareevlakte (-CC), *Barnard BOL 24788*, SAM 68461; 10 mls from Montagu towards Ladismith (-CD), *Hurley & Neil BOL 20177*,

Lewis BOL 21648 (BOL, PRE); Kleinvlakte near Barrydale (-DC), *Van Breda* 4379 (PRE, K).

Without precise locality: Ex hort. *Barnard*, NBG 10/67; "Probably sent by Watermeyer from Vanshynsdorp", BOL 18050.

T. watermeyeri consists of small plants with flowers more or less resembling those of *T. securigera*, but differing in the perianth having a somewhat more two-lipped appearance. The distinctive character of *T. watermeyeri* is its rather flaccid, often spirally twisted leaves which have undulate margins.

The species is not closely related to *T. tugwelliae* or to *T. undulata* both of which have leaves with undulate margins, but have flowers without calli. These therefore belong to other sections of the genus.

21. *Tritonia drakensbergensis* De Vos, sp. nov.

Caulis 250–300(–500) mm longus. *Folia* 4–5, linearia, acuminata, erecta, 150–250(–300) × 1,5–3(–4) mm, nervo valido in medio et prope margines praedita. *Spica* subsecunda, floribus (2–)3–7. *Bractae* fere chartaceae, 7–11 mm longae, cinnamomeae; bractea exterior subobtusata vel irregulariter dentata vel 3-dentata, nervo medio prominenti; interior basin versus pallida, binervata, bidentata, dentibus acuminatis, marginibus latis chartaceis. *Flores* zygomorphae, (22–)25–32 mm longi, miniati. *Tubus perianthii* late infundibularis, 8–10 mm longus, brevior segmentis; *segmenta* longitudine subaequalia, 15–20 × ca. 5–8 mm, segmento postico parum latiore, segmentis anticis tribus in fauce callo flavo subtriangulari praeditis. *Stamina* segmentum posticum versus posita; *filamenta* ca. 9–12 mm longa; *antherae* 5–6 mm longae, contiguae, infra vel supra medium segmentorum attingentes. *Stylus* 14–18 mm longus, ramis stigmaticis ad vel supra apices antherarum attingentibus.

Type: Cape, Transkei. Little Bush, Cala, 4 000', *Pegler* 1699 (BOL, holo-).

Plants 250–300(–500) mm long. *Corm* not seen. *Scape* 250–300(–450) mm long, simple, erect or slightly curved. *Leaves* 4–5, linear, acuminate, rather rigid, erect, 150–250(–300) × 1,5–3(–4) mm, with a strong middle vein and a prominent vein near each edge (dried state), almost reaching the base of the spike. *Spike* subsecund, lax, with (2–)3–7 flowers. *Bracts* almost papery, golden-brown, 7–11 mm long; *outer* subobtusate or irregularly toothed or 3-toothed, with a prominent median vein; *inner* pale towards the base, bidentate, 2-veined, with acuminate teeth and wide papery margins. *Flowers* zygomorphic, (22–)25–32 mm long, red or pinky-scarlet. *Perianth tube* widely funnel-shaped, 8–10 mm long, shorter than the segments; *segments* subequal in length, 15–20 × ca. 5–8 mm, with the posticous segment widest, and the three anticous segments with an almost triangular yellow cal-

lus in the throat. *Stamens* and *style* curved towards the posticous segment; *filaments* ca. 9–12 mm long; *anthers* contiguous, 5–6 mm long, curved, reaching less than, to more than halfway up the perianth segments. *Style* 14–18 mm; *stigmatic branches* 2,5 mm long, at or above the anther tips. *Capsules* not seen.

Flowering period: January to early March.

Distribution: on the southern parts of the Drakensberg range in the north eastern Cape Province and Transkei, at altitudes of 1 100 to 2 300 m (Fig. 22).

TRANSKEI—3127 (Lady Frere): In monte Kwenkwe in ditone Maclear (-DA), *H. Bolus s.n.*, Jan. 1896 (BOL); Little Bush, Cala, *Pegler 1699* (BOL).

—3128 (Umtata): Drakensberg, on Tsitsu footpath, distr. Maclear, *Galpin 6849* (BOL, GRA, PRE, K); Engcobo Mountain (-CA), *Flanagan 2659* (BOL).

CAPE—3028 (Matatiele): Naudésnek (-CA), *Marais 1374* (PRE).

—3127 (Lady Frere): Mountain 2,5 mls NE of Barkley Pass (-BB), *Nordenstam 2009* (S, PRE).

This species is distinguished by red (Galpin) or pinkish-scarlet (Nordenstam) flowers with a wide funnel-shaped perianth tube about half the length of the segments and with a yellow callus on each of the three antiscous segments; and by its long, linear, rather rigid erect leaves with three prominent veins, two of which are near the leaf edges.

It is closely related to the *laxifolia* – *nelsonii* – *strictifolia* complex, resembling the narrow-leaved specimens of *T. nelsonii* in habit. It differs from all three species of the complex in its shorter perianth tube; from *T. laxifolia* and *T. nelsonii* also in its leaves with prominent near-marginal veins and flowers with shorter calli; and from *T. strictifolia* in its much longer, linear leaves and different flowering period.

22. ***Tritonia nelsonii*** Bak. Handb. Irid. 195 (1892) & in Fl. Cap. 6: 127 (1896); Verdoorn, in Flow. Pl. Afr. 33 pl. 1315 (1959). Type: Transvaal, Houtbosberg mountain summit, *Nelson 440* (K, holo-; PRE, iso-).

T. petrophila Bak. in Bull. Herb. Boiss. Ser. 2, 4: 1004 (1904). Type: Transvaal, Granitfelsen bei Modderfontein, *Conrath 585* (Z, holo-; K).

Icon.: Flow. Pl. Afr. 33 pl. 1315; Letty pl. 38 (1962).

Plants (250–)500–900 mm long. *Corm* 15–30 mm diam., ovoid; tunic fibres fine, reticulate in the upper half, parallel in the lower. *Scape* (250–)500–900 mm long, slender, simple or with 1–2 branches. *Leaves* 4–8, suberect or slightly spreading, linear, acuminate, firm, striate, (200–)450–900 × 1,5–4(–6) mm, reaching from below to sometimes above the spike; cauline leaves 1–2, slightly shorter. *Spike* somewhat lax, almost secund, often 1–2-branched, with 5–12 or more suberect flowers. *Bracts* membranous but

greenish at the base at first, brown or minutely brown-striped in the upper half and along the edges, (8-)10-15 mm long; *outer* 3-toothed or acute, striate, with a stronger median vein; *inner* bidentate, 2-veined, shorter than the outer. *Flowers* (22-)25-35(-38) mm long, light flame to bright orange-red or bright red, with a high greenish-yellow callus on each anticus perianth segment. *Perianth tube* funnel-shaped, (10-)14-18 mm long, equal to or slightly longer or rarely shorter than the segments; *segments* unequal, oblanceolate, obtuse, (10-)12-17 × 5-10 mm, the posticus segment slightly hooded, to 10 mm wide, others narrower, spreading or recurved, the three anticus segments with a high greenish-yellow callus on a red-margined blotch, and with a pale dorsal median band. *Stamens* curved against the posticus segment; *filaments* 12-14 mm long, white; *anthers* 5-6 mm long, contiguous, with purple lateral lines, reaching the middle or higher up the perianth segments; pollen pale yellow. *Style* 17-25 mm, white; *stigmatic branches* 2-3 mm long, rarely overtopping the anthers. *Capsules* subglobose to shortly ellipsoid, membranous, 7-10 mm long; *seeds* shiny black, finely foveolate-reticulate, 2 mm diam.

Flowering period: (December to) February to March (to June).

Distribution: northern Transvaal and throughout the Highveld of Transvaal (Fig. 22).

TRANSVAAL—2229 (Waterpoort): Hangklip-Louis Trichardt (-DD), *Bremekamp & Schweickerdt* TM 29855 (PRE); Soutpansberg, Dr. Bird's farm, *Meeuse* 9785 (PRE, SRGH, S).

—2230 (Messina): Entabeni. Laastgevonden (-CC), *Koker* 22 (PRE).

—2329 (Pietersburg): Happy Rest (-BA), *Gerstner* 6103 (PRE); Louis Trichardt (-BB), *Breyer* 19491 (PRE); Houtbosberg (-DD), *Schlechter* 4408 (GRA, PRE); Near Haenertsburg (-DD), *Prosser* 1918 (PRE), *Codd* 9439 (PRE, K).

—2330 (Tzaneen): Broederstroom. Letaba (-CD), *Leighton* 3215 (PRE).

—2427 (Thabazimbi): Farm Groothoek, western extremity of Waterberg (-BC), *Codd* 3988 (PRE); Witpoortjie Falls (-CA), *Davey* 59 (NU).

—2526 (Zeerust): Zeerust (-CA), *Jenkins* TM 11665 (PRE); Kraalkop (-CD), *De Wit* 957 (PRE); Swartruggens (-DA), *Fouche* PRE 36618.

—2527 (Rustenburg): Rustenburg (-CA), *Rogers* 23436 (K); Farm Rainhill near Rustenburg, *Codd* 1080 (PRE); Hennops River (-DA), *Repton* 496 (PRE); Pelindaba (-DD), *Strey* 3046 (PRE); Uitkomst, Rustenburg, *Coetzee* 724 (PRE).

—2528 (Pretoria): Kameeldrift road 35 mls NE of Pretoria (-BC), *Repton* 3713 (PRE); Lynwood (-CA), *Marsh* PRE 28583 (K), *Verdoorn* 2416 (PRE); Onderstepoort (-CA), *Pole Evans* 429 (PRE); Near Onderstepoort, *Meeuse* 9242 (SRGH); Near Silverton (-CB), *Repton* 382 (PRE); Fountains (-CC), *Munro* PRE 57229, *Verdoorn* 723 (PRE); Premier Mine (-DA), *Rogers* 25369 (PRE); Renosterkop, Bronkhorstspuit district (-DB), *Young* 2149 (PRE, K).

—2529 (Witbank): Loskopdam, Nooigedagt (-AD), *Theron* 1212 (PRE); Middelburg (-CD), *King* s.n. (C).

—2530 (Lydenburg): Waterval Boven (-CB), *Taylor* 1967 (PRE).

—2626 (Klerksdorp): Lichtenburg (-AA), *Jenkins* TM 11478 (PRE); 15 mls NW of

Ventersdorp (-BA), *Codd* 2660 (PRE), *Sidey* 97 (S); Goedgedacht, Ventersdorp (-BD), *Sutton* 567 (PRE).

—2627 (Potchefstroom): 6 mls N of Fochville (-AD), *Dahlstrand* 869 (C); Near Krugerdorp (-BB), *Meeuse* 9060 (L); Little Falls, Roodepoort Ridge (-BB), *Mogg* 20233 (PRE).

—2628 (Johannesburg): Modderfontein (-AA), *Conrath* 585 (K, Z); Near Johannesburg, *Robinson* 57 (NU), *Tucker s.n.* (BOL), *Rogers* 19234 (NH); Weltevreden 10 mls NW of Johannesburg, *Mogg* 22674A (PRE); Zoo Kopjes, *Moss* 8604 (BM, K, PRE); Heidelberg (-AD), *Leenderts* 1024 (BOL), *Burt-Davy* 3098 (PRE), *Srey* 3065 (PRE); Heidelberg Kloof (-AD), *Mogg* 20500 (PRE); Suikerbosrand Nature Reserve (-AD/-CA), *Kroon* 189 (PRE), *Bredenkamp* 441 (PRE).

Without precise locality: Bechuanaland, *Pole-Evans & Ehrens* 1915 (K, SRGH).

This species is closely related to *T. laxifolia*, differing from this in its funnel-shaped perianth tube which widens from close to its base, and in its longer, narrower, linear leaves narrowing gradually to an acuminate tip. The veins are closely spaced and the leaves appear striate in the dried condition. Leaves in shade are less striate. The calli on the anticus perianth segments resemble those of *T. laxifolia*.

Two growth forms occur which were formerly treated as distinct species. In moister regions the plants are somewhat lax with fewer and larger flowers; in dryer areas they are more erect and have smaller flowers (Verdoorn, 1959).

23. *Tritonia atrorubens* (N.E.Br.) L. Bol in J. Bot. Lond. **67**: 133 (1929).

Gladiolus atrorubens N.E.Br. in Kew Bull. **1914**: 135 (1914). Type: Transkei, Kentani, near Manubi, *Saxton* 13 (K, holo-).

T. flanaganii L. Bol. in Ann. Bol. Herb. **2**: 161 (1918). Syntypes: Cape, near Impetu between Komga & Kei Mouth, *Flanagan* 55 (BOL, lecto-); Transkei, flats near Kentani, *Pegler* 392 (BOL, GRA).

Plants 300–600 mm long. *Corm* globose, 10 mm diam.; tunic fibres reticulate in upper half, parallel towards the base. *Scape* 300–600 mm long, erect, slender, simple. *Leaves* 3–6, linear, erect, acuminate, striate with three or more strong veins, 150–400 × (1–)2–5 mm, reaching or almost reaching the base of the spike; cauline leaves 2–4, 100–200 mm long, subulate. *Spike* somewhat secund, rather lax, with 2–9 flowers. *Bracts* membranous, 8–10 mm long, brown in the upper half; *outer* acute or acuminate or irregularly toothed, veined, the median vein brown upwards; *inner* slightly shorter, bidentate, 2-veined, with wide, pale, subhyaline margins. *Flowers* obliquely funnel-shaped, 25–30 mm long, dark red, drying to a blackish purple-red. *Perianth tube* 15–17 mm long, funnel-shaped, almost straight, 1.5 to almost 2 times the length of the segments; *segments* subequal, oblong, obtuse, 8–12 × 4–8 mm, the posticus segment wider than the others, the

anticous segments each with a high callus, with that on the median segment larger than on the lateral ones and yellow. *Filaments* 10–11 mm, reddish; *anthers* 5–7 mm long, dark, reaching more than halfway up the perianth segments. *Style* 18 mm, reddish; *stigmatic branches* 3–4 mm long, reaching the anther tips.

Flowering period: December to January.

Distribution: on a small area hardly 50 km in extent, west and east of the Cape–Transkeian border, at low altitude (Fig. 22).

CAPE–TRANSKEI—3228 (Butterworth): Kentani, near Manubi (-BC), Saxton 13 (K); Near Mpetu (-CA), Flanagan 55 (Bol, PRE); Near Kentani (-CB), Pegler 392 (BOL, GRA, PRE).

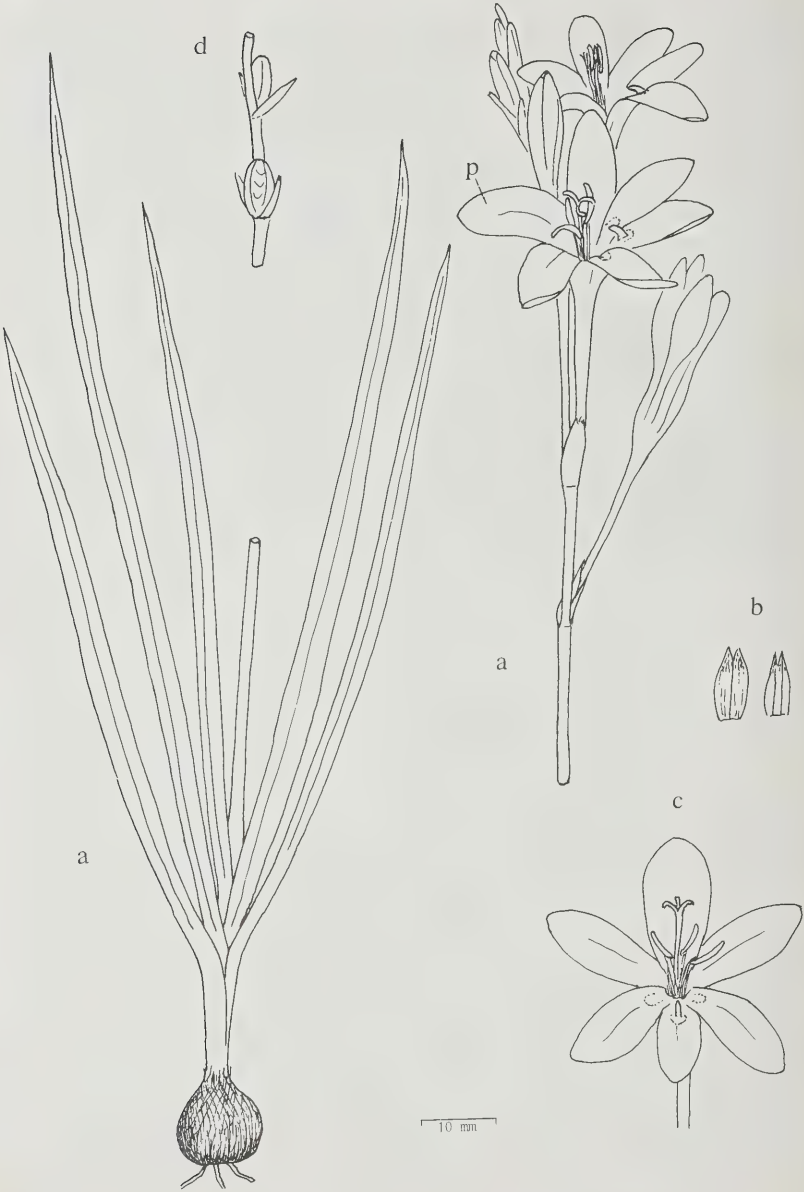
Without precise locality: Marloth 8624 (PRE); Transkeian Country, Bowker 207 (K).

This rare species, found only a few times near the southern part of the Cape–Transkeian border, is distinguished by its long, narrow, linear leaves with a structure almost like that of *T. Bakeri*, by its outer bracts often with acute or acuminate tip, and its dark red flowers which, on drying out, become reddish-black, and which have a perianth tube longer than the segments and calli on the lower segments. The callus on the median anticous segment is yellow and larger than the lateral ones which seem to be dark in colour (red?).

24. *Tritonia moggii* Oberm. in *Kirkia* 3: 24 (1963). Type: Mozambique, Inhaca Island, Ridge Woodland SW of Saco Bay, Mogg 27315 (PRE, holo-; J, SRGH).

Icones: Unpublished, by M. Walgate, in BOL; this work Fig. 26.

Plants (200–)300–500 mm long. *Corm* 10–15 mm diam., globose, sometimes with small cormlets at the ends of 20–30 mm long stolons; tunic fibres fine, elongated-reticulate. *Scape* erect, simple or with 1–3 branches, (200–)300–500 mm long. *Leaves* 6–9, linear-lanceolate, acuminate, soft textured, 150–400(–500) × 4–8(–11) mm, sometimes overtopping the spike, with a prominent middle vein and a prominent lateral vein almost on each leaf edge; cauline leaves shorter and narrower. *Spike* almost secund, lax, simple or few-branched, with 8–10 or more flowers. *Bracts* membranous, papery, 6–12(–15) mm long, brown or reddish-brown in the upper half, with acuminate teeth; *outer* finely veined, acute or 2–3-toothed, with the median tooth often reduced; *inner* bidentate, 2-veined, equal to or slightly shorter than the outer. *Flowers* (40–)45–55 mm long, orange-pink or salmon-pink, with a yellow, red-margined blotch on the three anticous perianth segments.



Perianth tube (24–)30–35(–40) mm long, narrowly tubular for most of its length, widened slightly near the top; *segments* oblong-lanceolate, obtuse (12–)15–22 × 6–9 mm, the median posticous segment slightly wider, the median anticous, and sometimes also one or both lateral anticous segments with a yellow callus. *Filaments* 12–16 mm; *anthers* 6–7 mm long, curved, reaching halfway or higher up the perianth segments. *Style* 33–40 mm; *stigmatic branches* ca. 4 mm long, reaching or overtopping the anthers. *Capsules* ellipsoid or turbinate, membranous, 8–15 mm long; *seeds* round, shiny black, finely reticulate-foveate, ca. 2 mm diam.

Flowering period: April to July, rarely to October.

Distribution: Mozambique, coastal regions and Inhaca Island, as well as in the inland district of Gaza (Fig. 22).

MOZAMBIQUE—Gaza, between Manjacaze & the Coolelo monument, *Lemos & Balsinhas* 115 (PRE); Masiene, *Van Dam* PRE 58376, TM 25358 (PRE); Chibuto, 8 km depois de Maniquenique, *Lemos & Balsinhas* 138 (PRE); Maniquenique Expt. Estação, *Barbosa & De Lemos* 7599 (SRGH); Chicumbane, *Junod* 355 (PRE); Sul do Save, *Pedro & Pedrogao* 1331 (PRE, K); Quelimane, *Sim* 20507 (PRE); Inhambane, *Gomes & Sousa* 1876 (K); Inhaca Island, *Barbosa* 7630 (PRE, K), *Mogg* 27315 (PRE, SRGH), *Weintraub* J20439 (BOL, SRGH), *Hancock* J28015 (PRE); 100 mls NW of Lorenzo Marques (Maputo), *Debenah* s.n. (STE).

This species is readily distinguished by its somewhat zygomorphic flowers with a perianth tube considerably longer than the segments and usually a single callus, and by its leaves that have a prominent vein almost on each leaf margin. It stands nearest *T. laxifolia* and *T. nelsonii* which have a shorter perianth tube and three calli. Several collections seem to connect the species with *T. laxifolia*, e.g., *Van Dam* s.n. (PRE 58376), *Lemos & Balsinhas* 138 (PRE) and *Barbosa & De Lemos* 7599 (SRGH). These show a small callus also on one or both lateral anticous perianth segments. These plants have perhaps incorporated some genes of *T. laxifolia*. They are from the Gaza district of Mozambique which is near the border with Malawi where *T. laxifolia* occurs.

Some of the flowers of the Pedro & Pedrogao collection no. 1331 are only 35 mm long with a perianth tube of 18 mm.

25. *Tritonia delpierrei* De Vos, sp. nov.

Fig. 27.

Plantae 230–350 mm longae. *Cormus* ovoideus, 12–25 mm diam., fibris tunicae validis, elongato-reticulatis, basin versus subparallelis. *Caulis* rigidulus, aliquantum flexuosus, suberectus, 230–350 mm longus, base collo folio-

FIG. 26

Tritonia moggii (from a drawing by M. Walgate in BOL): a, plant; b, outer (left) and inner (right) bract; c, flower, front view; d, capsules; p, posticous perianth segment.

rum veterum circumnixa, 1–3-ramosus. *Folia* 3–5, linearia, acuminata, subsucculenta, $120\text{--}300 \times 2\text{--}3\text{--}(4)$ mm, suberecta vel leviter patula, subglaucula. *Spica* laxa, subsecunda vel interdum subdisticha, ramo principali 5–9-florenti. *Bracteae* in dimidio superiore membranaceae, minute sphacelatae, apicibus brunneis, in dimidio inferiore viridulae, 5–10 mm longae; *bractea exterior* minute 2–3-dentata vel subacuta vel subobtusata; *interior* interdum parum brevior quam exterior, bidentata, binervis. *Flores* subzygomorphi, in medio diei fere hypocrateriformes, 22–25(–28) mm longi, eburnei et flavidi, leviter fragrant. *Tubus perianthii* tubularis, 12–18 mm longus, 1,5–2-plo longior quam segmenta, in dimidio superiore gradatim dilatatus ad 2 mm diam.; *segmenta* 8–10(–12) mm longa, patentia, obtusa, segmentis posticis ellipticis, eburneis, 3–5 mm latis, segmentis anticis oblanceolatis, flavidis, 3–4 mm latis, in quoque callo flavido ad 1 mm alto. *Stamina et stylus* parum segmentum posticum versus positi, eburnei; *filamenta* 5–7 mm longa; *antherae* contiguae, 3–5 mm longae, supra dimidium segmentorum attingentes. *Stylus* 18–25 mm longus, ramis stigmaticis 1,5–2 mm longis, supra apices antherarum attingentibus. *Capsulae* subrotundo-trilobatae, 5–10 mm longae, seminibus protuberantibus, globosis, brunneis, minute reticulatis, 2 mm diam.

Type: Cape, southern Richtersveld, top Helskloof, *De Vos* 2462 (STE, holo-).

Plants 230–350 mm long. *Corm* ovoid, 12–25 mm diam.; tunic fibres strong, elongate-reticulate, almost parallel towards the base. *Scape* rather rigid, slightly flexuose, suberect, 230–350 mm long, with a collar of old leaf bases up to 60 mm long around the base, 1–3-branched, the branches somewhat divergent at their bases, then ascending. *Leaves* 3–5, linear, acuminate, slightly succulent, $120\text{--}300 \times 2\text{--}3\text{--}(4)$ mm, suberect or slightly spreading, lightly glaucous, with a strong middle vein or sometimes two strong veins; cauline leaves 1–3, 10–60 mm long. *Spike* lax, subsecund or sometimes subdistichous, with 5–9 flowers on the main branch. *Bracts* membranous and minutely sphacelate in the upper half, with brown tips, greenish in the lower half, 5–10 mm long; *outer* minutely 2–3-dentate, or shortly subacute or subobtusata; *inner* sometimes slightly shorter than the outer, 2-veined, 2-dentate with acuminate teeth. *Flowers* slightly zygomorphic, sometimes inverted, almost salver-shaped in the middle of the day with spreading segments, 22–25(–28) mm long, cream and pale yellow, sometimes faintly flushed with purplish-pink on drying, faintly fragrant. *Perianth tube* tubular, 12–18 mm long, 1,5–2 times longer than the segments, gradually widened in the upper half to 2 mm diam.; *segments* (8–)10–12 mm long, spreading, obtuse, posticous segments elliptical, cream, 3–5 mm wide; anticus segments oblanceolate, pale yellow, 3–4 mm wide, each with a small yellow callus up to 1 mm high on the lower half. *Stamens* and *style* placed nearer the post-



FIG. 27

Tritonia delpierrei (De Vos 2462): 1a, plant; 1b, outer (left) and inner (right) bract; 1c, flower half in a median longitudinal cut; 1d, capsules.
Tritonia marlothii (from a drawing of Marloth 12296 in BOL): 2, flower.

cous side of the flower, cream; *filaments* 5–7 mm long, inserted near the top of the perianth tube; *anthers* contiguous, 3–5 mm long, reaching above the middle of the perianth segments, with pale yellow pollen. *Style* 18–25 mm; *stigmatic branches* 1.5–2 mm long, slightly expanded at their tips, overtopping the anthers. *Capsules* subrotund-trilobed, 5–10 mm long, with bulging seeds; *seeds* globose, brown, finely reticulate, 2 mm diam. *Chromosome number* $2n = 20$ (f. Goldblatt).

Flowering period: late July to early October, probably depending on the beginning of the rainy season.

Distribution: southern Richtersveld, Namaqualand (Fig. 22).

CAPE—2817 (Vioolsdrif): Helskloof, between Stinkfontein and Orange River (-CD), *Delpierre s.n.*, Sept. 1977 (MO); Top Helskloof, between Modderdrif and Eksteensfontein, *Delpierre s.n.* NBG 118049; Cultivated from seed, *Goldblatt 4984* (MO); Top Helskloof, *De Vos 2453* (STE); Cultivated from corms, *De Vos 2462* (STE).

The range of this new species, as well as that of *T. marlothii*, is far distant from other species of *Tritonia*, their nearest neighbours being *T. karooica* and *T. kamisbergensis*. Possibly *T. delpierrei* stands nearest *T. karooica* which also has yellow, only slightly zygomorphic flowers with a perianth tube longer than the segments and calli on the lower segments, as well as capsules with large, bulging seeds. They differ, however, in their general habit, *T. delpierrei* being a more slender plant with narrower, more erect, slightly succulent leaves and paler flowers which become almost salver-shaped in the middle of a hot day and which have smaller, spreading, but not reflexed, segments. In late afternoon the flowers close somewhat, the three lower segments becoming grouped closer together. This gives the flowers a somewhat two-lipped appearance, more or less resembling other species of section *Montbretia*.

The species was discovered by Prof. G. R. Delpierre, whence the name. It seems to be quite common in the southern part of the Richtersveld towards and at the top of Helskloof.

26. *Tritonia marlothii* De Vos, sp. nov.

Fig. 27.

T. delpierrei affinis, foliis et habitu similaribus; differt imprimis floribus et stylo longioribus et tubo perianthii 3–4-plo longiore quam segmentis.

Type: Cape, Richtersveld, *Marloth 12296* (BOL, holo-; PRE).

Plants 200–350 mm long. *Corm* not seen. *Scape* rather rigid, slightly flexuose, suberect, 200–350 mm long, 2–3-branched. *Leaves* 4–5, linear, acumi-

nate, slightly succulent, $100\text{--}240 \times 1.5\text{--}3\text{--}(4)$ mm, with one or two prominent veins; cauline leaves 1–2, 30–50 mm long. *Spike* distichous, rather lax, with 6–12 flowers on the main branch. *Bracts* membranous, almost papery and finely sphacelate in the upper half, with dark brown tips, 7–10 mm long; *outer* obtuse or minutely 2–3-toothed; *inner* bidentate with short acuminate teeth. *Flowers* slightly zygomorphic, somewhat salver-shaped, 35–45 mm long, apparently pink. *Perianth tube* tubular, slightly curved, 28–35 mm long, 3–4 times the length of the segments, gradually widened in the upper half to 2 mm diam.; *segments* oblanceolate or oblong, obtuse, spreading, $8\text{--}10 \times 2.5\text{--}4$ mm, with a small yellow callus ca. 1 mm high on the lower half of each anticus segment. *Filaments* 6–8 mm long; inserted near the top of the perianth tube; *anthers* contiguous, 4 mm long, reaching above the middle of the segments. *Style* 32–40 mm; *stigmatic branches* 1.5–2 mm long, overtopping the anthers. *Capsules* subrotund-trigonus or shortly obovoid-trigonus, 6–10 mm long; *seeds* subglobose, dark brown, 2 mm diam., minutely reticulate-foveolate.

Flowering period: late August to September.

Distribution: southern Richtersveld, Namaqualand (Fig. 22).

CAPE—2817 (Vioolsdrif): Brakfontein (-CC), Marloth 12296 (BOL, PRE).

This new species, found only once in 1925, is very closely related to *T. delpierrei*, being similar to the latter except for its longer flowers, longer perianth tube and style, and perhaps different flower colouring. The flower colour of the dried specimens have been noted on the herbarium sheet in PRE as “apparently pink” and in BOL as “flowers appear purple to pink, pale”. The note in BOL is not in Marloth’s handwriting. There is a possibility that the flowers may be cream or pale yellow, like those of *T. delpierrei* which sometimes tend to become flushed with purplish-pink on drying out. Whether the bracts are greenish in their lower half as in *T. delpierrei*, could not be determined.

As no intermediates between the two taxa have as yet been found, they are here treated as separate species.

27. *Tritonia karooica* De Vos, sp. nov.

Fig. 28.

Plantae 100–200(–230) mm longae. *Cormus* ovoideus, basi subcomplanatus, 10–25 mm diam., fibris tunicae validis, superne elongato-reticulatis, basin versus subparallelis. *Scapus* 40–150 mm longus, interdum 1-ramosus, circa basin fibris veteribus. *Folia* 6–10, disticha, flabellata, lanceolata-falcata, reflexa, percurvata vel expansa, $40\text{--}100\text{--}(150) \times 3\text{--}7$ mm. *Spica* flexuosa, floribus 2–6 vel raro pluribus. *Bracteae* membranaceae, (12–)15–20 mm

longae; *bractea exterior* acuta v. 3-dentata, apicem versus subtiliter sphacellata, porphyreo-nervi; *interior* bidentata, binervi. *Flores* leviter zygomorphi, infundibulares, demum segmentis perianthii reflexis, 40–60 mm longi, plerumque ochracei, armeniaco suffusi, fusco venosi, fragrantis. *Tubus perianthii* 25–32 mm longus, infundibularis; *segmenta* obovato-spathulata, obtusa v. subobtusata, 12–18 mm longa, longitudine subaequalia, segmenta postica 7–12 mm lata, mediano latissimo, segmenta antica 6–7 mm lata, in quoque callo luteo vix 1 mm alto. *Stamina* segmentum posticum versus curvata; *filamenta* 15–22 mm longa; *antherae* curvatae, fere dimidium segmentorum attingentes. *Stylus* 28–35 mm longus; *rami stigmatici* antheras attingentes v. parum superantes. *Capsulae* breviter ellipsoideo-trigonae v. obovoideo-trigonae, seminibus leviter protuberantibus, globosis, brunneis, ca. 2 mm diam., subtiliter reticulato-foveatis.

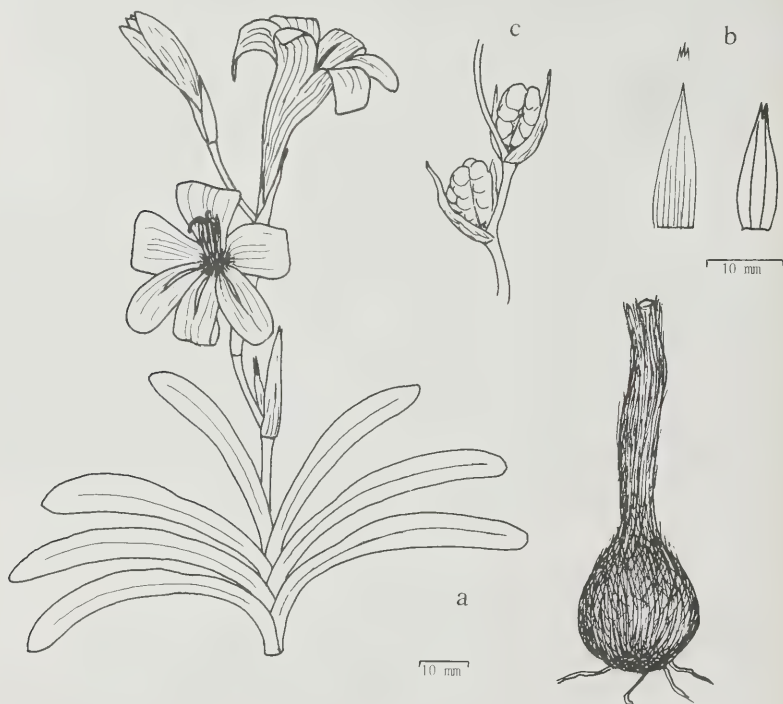


FIG. 28

Tritonia karooica (De Vos 2259, 2458): a, plant; b, outer (left) and inner (right) bract; c, capsules.

Type: Cape, Murraysburg, *Tyson 311* (BOL, holo-; NH, SAM, BM, K).

Plants 100–200(–230) mm long. *Corm* ovoid, somewhat flattened at the base, 10–25 mm diam.; tunic fibres strong, elongated-reticulate above, at the base subparallel and often somewhat plate-like. *Scape* 40–150 mm long, sometimes with one branch, with a short collar of old fibres around its base. *Leaves* 6–10, lanceolate-falcate, acute or obtuse, in a dense, fan-shaped distichous basal group, usually strongly curved, reflexed or spreading, 40–100(–150) × 3–7 mm, with a prominent middle vein. *Spike* distichous, flexuose, with 2–6 or rarely more flowers. *Bracts* membranous, papery, (12–)15–20 mm long; *outer* acute or 3-toothed with the middle tooth longest, finely sphacelate towards the tip, with reddish-brown veins; *inner* bidentate, 2-veined. *Flowers* slightly zygomorphic, funnel-shaped, ultimately with reflexed perianth segments, 40–60 mm long, usually dull yellow or brownish-yellow or sometimes cream, orange or salmon, flushed with orange or pink outside, conspicuously dark-veined, fragrant in the evening. *Perianth tube* 25–32 mm long, funnel-shaped, narrow in the lower half, widened gradually in the upper half to ca. 8–10 mm diam; *segments* obovate-spathulate, obtuse or subobtuse, 12–18 mm long, subequal in length, upper segments 7–12 mm wide, the median one widest, anticus segments 6–7 mm wide, each with a yellow callus 6–10 mm long and hardly more than 1 mm high. *Stamens* curved towards the posticus segment; *filaments* 15–22 mm; *anthers* 6–7 mm long curved, reaching about halfway up the perianth segments. *Style* 28–35 mm; *stigmatic branches* 4–5 mm long, reaching or slightly overtopping the anthers. *Capsules* shortly ellipsoid-trigonus or obovoid-trigonus, with bulging seeds, 8–12 mm long; *seeds* globose, brown, finely reticulate-foveate, ca. 2 mm diam.

Flowering period: August to September, sometimes to October.

Distribution: widespread throughout the western and north western parts of the Great Karoo, mostly above the Nuweveld escarpment (Fig. 22).

CAPE—2918 (Gamoep): Areb (-AC), *Barker 8364* (NBG, PRE), *Lewis SAM 65405* (PRE); About 30 mls NE of Springbok (-CB), *Lewis 3501* (SAM); 20 mls NE of Springbok (-CA), *Barker 6670* (BOL, NBG).

—2919 (Pofadder): 5 mls NE of Pofadder (-AB), *Lewis SAM 65406* (PRE); Between Bladgrond and Pofadder (-BA), *Barker 8340* (NBG, STE).

—2922 (Prieska): Prieska (-DA), *Bryant 1140* (BOL, PRE, K), *Pole-Evans 18803* (PRE).

—2923 (Douglas): Strydenburg (-DC), *Schweickerdt 2604* (PRE); South of Strydenburg, *Taylor 855* (BOL).

—3018 (Kamiesberg): Dabidas farm, ca. 5 km SE of Aalwynsfontein (-BC), *Thompson 2853* (PRE).

—3021 (VanWyksvlei): Jasperskop, ca. 20 mls N of VanWyksvlei (-BB), *Stayne, s.n.*, 21/8/63 (NBG, STE).

—3022 (Carnarvon): Carnarvon (-CC), *Curry BOL 13682*.

- 3118 (VanRhynsdorp): Nuwefontein, fired at Whitehill, *Archer* 683 (BOL).
 —3119 (Calvinia): Calvinia (-BD), *Hanekom* 2114 (PRE), *Schmidt* 335 (PRE).
 —3120 (Williston): 20 mls E of Calvinia (-AC), *Barker* 9520 (NBG, STE); 16 mls W of Williston (-BC), *Acocks* 14695 (PRE); Near Williston (-BD), *Schlieben* 9159 (PRE); Rietfontein, *Hanekom* 2114 (MO); Between Middelpoos and Calvinia (-CC), *Goldblatt* 566 (BOL).
 —3121 (Fraserburg): Between Fraserburg and Carnarvon (-BD/-DA), *Hafström & Acocks* 280 (PRE, S); Fraserburg–Williston road (-BD), *De Vos* 2259 (STE).
 —3123 (Victoria West): Murraysburg (-DD), *Tyson* 311 (BOL, SAM, BM, K, NH).
 —3124 (Hanover): Hanover (-AB), *Burger s.n.*, Sept. 1907 (GRA).
 —3221 (Merweville): Layton, Leeugamka–Fraserburg road (-BB), *Shearing* 101 (PRE); *Shearing* sub *De Vos* 2458 (STE).
 Without precise locality: Bushmanland, *Bolus* 31779. (BOL).

This very distinct species has been mistakenly identified in South African herbaria as *T. flava*. An examination of the holotype of the latter in BM showed that the present species is, except for the yellow colour of the flowers, totally different. It differs from *T. flava* in its narrower, usually recurved, distichous leaves spread fan-wise, and in its perianth with dark veins, long perianth tube, and long, but low, calli on the lower segments.

T. karooica is readily distinguished by its usually strongly reflexed leaves and large funnel-shaped, usually brownish-yellow flowers often flushed with orange or pink outside, with a perianth tube about twice the length of the segments, which have five or more dark longitudinal veins, and later become strongly reflexed; the calli on the anticus perianth segments are long but hardly more than 1 mm in height.

28. *Tritonia florentiae* (Marl.) Goldbl. in Bothalia 11: 281 (1974).

Gladiolus florentiae Marl. in Trans. Roy. Soc. S. Afr. 2: 241 (1912).
 Type: Cape, near Groot Tygerberg, Prince Albert district, *Marloth* 4452 (PRE, holo-; BOL).

Montbretiopsis florentiae (Marl.) L. Bol. in S. Afr. Gard. 19: 215 (1929); Phillips, Gen. S. Afr. Flow. Pl. ed. 2, 219 (1951).

Icones: Marloth, Fl. S. Afr. 4: t. 47a (1915); this work **Fig. 29**.

Plants 70–120 mm long. *Corm* ovoid to pear-shaped, 10–15 mm diam.; tunic fibres very fine, elongated-reticulate. *Scape* very short, hidden by leaf sheaths and leaf remains which form a collar ca. 30 mm long around the base. *Leaves* 4–8, basal, distichous, scimitar-shaped, recurved, acute to sub-acute, 50–70 × 3–6 mm, with a slender middle vein. *Inflorescence* with 2–3(–4) flowers, each terminal on its own peduncle of ca. 10 mm and subtended by a pair of bracts. *Bracts* membranous, papery, very thin, soon crumpled, 12–18 mm long, pale straw-coloured, finely stippled or striate with short brown lines, hidden by the leaf sheaths; *outer* greenish in the low-



FIG. 29

Tritonia florentiae (De Vos 2282): a, plant and front view of flower; b, flower half in a median cut.

er part, acute, soon lacerated at the tip; *inner* bidentate. *Flowers* zygomorphic, (32-)44-50 mm long, bright yellow (RHS 12A, B), reddish in the throat and with an arrow-shaped red mark on the lower segments. *Perianth tube* (15-)18-24 mm long, almost straight, tubular in the lower 8-10 mm, gradually widened and funnel-shaped upwards; *segments* unequal, (15-)20-25 mm long, obtuse to subacute, median posticous segment largest, obovate, 13-15(-18) mm wide, slightly concave, sometimes emarginate; lateral posticous 8-10 mm wide, oblanceolate, anticous segments 5-7(-9) mm wide, oblanceolate, each with a large, triangular, yellow callus with a crisped upper margin. *Stamens* curved towards the posticous segment, *filaments* 10-13 mm; *anthers* 5-6 mm long, contiguous, facing downwards, reaching above the middle of the posticous segment, yellow or purple with mauve or

whitish pollen. *Style* 25–30(–33) mm; *stigmatic branches* 3 mm long, often overtopping the anthers. *Capsules* inflated, ovoid to shortly ellipsoid, 15–20 mm long, each on its own stalk; *seeds* dark brown, round or angled, smooth, ca. 2 mm diam.

Flowering period: May to July.

Distribution: western and southern parts of the Great Karoo from Calvinia to Beaufort West and Prince Albert (Fig. 21).

CAPE—3119 (Calvinia): Stompiesfontein, *Compton 11151* (NBG); South of Bloukranspas on road to Ceres (-DC), *De Vos 2343* (STE).

—3219 (Wuppertal): Ceres district, 10 mls NE of Tulpfontein (-DB), *Acocks 14456* (PRE); Ca. 160 kms S of turnoff to Ceres from Calvinia (-DD), *Goldblatt 3921* (MO).

—3222 (Beaufort West): 14,5 mls S Beaufort West (-DA), *Acocks 20441* (PRE).

—3222 (Oudtshoorn): Prince Albert, N foot of Tierberg (-AB), *De Vos 2282* (STE); Tygerberg near Prince Albert, *Marloth 4452* (BOL, PRE).

T. florentiae comprises small plants readily distinguished by their short stem, distichous, recurved leaves, pale papery bracts hidden by the leaf bases, and bright yellow flowers with the three lower perianth lobes showing an arrow-shaped red mark above a large triangular callus which has a crisped upper edge.

The species has the habit, corm, and flower typical of *Tritonia* section *Montbretia*, but differs from all other *Tritonia* species in its inflorescence. On account of this L. Bolus placed it in a genus of its own, *Monbretiopsis*. The plant bears two to three, or rarely four, flowers each within its two bracts, terminal on a short peduncle which is produced in the axil of an upper foliage leaf. This inflorescence can be interpreted as a very reduced branched spike, each branch with a single flower. This character is analogous with that discussed by Goldblatt (1972) in *Anomatheca*, where one species, *A. fistulosa* has a branched inflorescence, each branch with a single terminal flower. The inflorescence of the present species differs from the latter in its much shorter branches which are hidden by the leaf sheaths.

SPECIES INSUFFICIENTLY KNOWN

Tritonia flava (Ait.) Ker-Gawl. in Kon. & Sims, *Ann. Bot.* 1: 228 (1805); Ait. *Hort. Kew.* ed. 2, 1: 92 (1810); non Ker-Gawl. 1823, nec Bak. 1892, 1896.

Gladiolus flavus Ait. *Hort. Kew.* 1: 65 (1789). Type: *Hort. Kew.* 1781 (BM, holo-).

Known only from its type in BM which is a very poor specimen comprising a scape with a single open flower and a few buds, a lateral branch with buds, two cauline leaves and basal leaf, and another loose basal leaf.

Scape ca. 150 mm long, flexuose with one branch. *Basal leaves* 130–140 × 7–10 mm, lanceolate, acuminate, with a strong middle vein; cauline leaves smaller. *Spike* lax, with few flowers. *Outer bract* pale brown, 15–25 mm long, narrowly lanceolate, acuminate, striate, with a stronger median vein and sphacelate papery margins; *inner* 15 mm long, bifid with 2 long acuminate points. *Flowers* 40 mm long, yellow (e descr.), suberect. *Perianth tube* ca. 25 mm long, funnel-shaped; *segments* ca. 15 × 4–5 mm, the three lower segments with an unguiform perpendicular callus (e descr.). *Anthers* 5 mm long. *Style* ca. 25 mm.

Distribution unknown.

It is not the same as *T. flava* Ker-Gawl. in Bot. Reg. 7 t. 747 (1823) (see under *T. securigera*), nor is it the species designated as *T. flava* in South African herbaria (see *T. karooica*).

T. fulva Dehnh. Cat. Horti Camald. ed. 2, 24 (1832) is, e descr., a *Tritonia* species, sect. *Montbretia*. Type not found.

T. magniflora Dehnh. ibid. is, e descr., perhaps *T. squalida* (Ait.) Ker-Gawl. Type not found.

T. pulchella Dehnh. ibid. is, e descr., perhaps *T. squalida* (Ait.) Ker-Gawl. Type not found.

T. tripunctata Dehnh. ibid. is, e descr., a *Tritonia* species, section *Montbretia*. Type not found.

T. undulata (N.L. Burm.) Bak. in J. Linn. Soc. 16: 163 (1877) partly as to name, excl. syn., & Handb. Irid. 191 (1892), & Fl. Cap. 6: 121 (1896) as to name but not as to plant described, and excl. all syn. except *I. undulata*; Foster in Contr. Gray Herb. N.S. 114: 46 (1936) as to name but not as to plant; non Marloth (1915).

Ixia undulata N.L. Burm. Prodr. Fl. Cap. 1 (1768); non Salisb. (1796). Type: Africa australis, Caput bonae Spei, Herb. Burman s.n. (G, holo-).

Tritonixia undulata (Bak.) Klatt in Abh. naturf. Ges. Halle 15: 357 (1882).

Tritonia undulata (N.L. Burm.) N.E.Br. in Kew Bull. 1929: 137 (1929).

Scape ca. 120 mm long, slender, slightly flexuose. *Leaves* 3, ca. 60–100 × 4–6 mm, acuminate, with crisped, finely ciliate, undulate margins and a strong middle vein. *Spike* lax, few-flowered. *Bracts* membranous, brown, 5 mm long; *outer* ovate, subobtusate or shortly lacerate; *inner* bidentate. *Flowers* 20–24 mm long, funnel-shaped, yellowish (fide Burman). *Perianth*

tube 10–12 mm long, funnel-shaped; *segments* subequal, oblong-lanceolate (linear, fide Burman), obtuse, 10–11 × 3 mm, probably without calli. *Anthers* 2 mm long, curved, fairly stout for their length, reaching halfway up the perianth segments. *Style* ca. 16 mm long, reaching the anther tips.

Distribution: Cape of Good Hope, without precise locality.

Linnaeus the younger (1781) combined two species under *Ixia crispa* when he cited *I. undulata* Burm. as synonym. His description, however, refers to *I. crispa* only. Ker-Gawler [Curtis's bot. Mag. t. 599 (1802)] also cited *I. undulata* as a synonym of *I. crispa* L.f. As Burman's epithet was the earlier one, Baker (1877), on transferring the taxon to *Tritonia*, named it *T. undulata* (Burm.f.) and cited Linnaeus's species as a synonym. The description, provided in 1892 by Baker, refers, like Linnaeus's description, to *I. crispa* only.

The error was discovered by N. E. Brown (1929) when he examined the Iridaceae of Burman's *Prodromus*. He thereupon described Burman's plant as *T. undulata* (Burm.f.) N.E.Br. and gave *I. crispa* L.f. a new name, *T. thunbergii*, since the name *T. crispa* had already been used for another species of *Tritonia*. See *T. thunbergii* under SPECIES EXCLUDED.

Foster (1936) realised that difficulties were involved in the acceptance of *T. undulata* (Burm.) N.E.Br. and indicated Burman's species only as *T. undulata* (Burm.f.) Bak. "as to name but not as to plant".

Burman's species is known only from its specimens in the Burman herbarium in Geneva. Superficially the plant looks like a species of *Tritonia*. Its anthers are, however, shorter and stouter than in any species of *Tritonia*, and it must perhaps be transferred to another genus, e.g. *Ixia*.

SECTIONS AND SUBGENERA EXCLUDED FROM *TRITONIA*

Section *Crocasma* (Planch.) Bak. in J. Linn. Soc. **16**: 163 (1877) (orthographic error) is *Crocasmia* Planch.

Section *Dichone* Salisb. ex. Bak. in J. Linn. Soc. **16**: 163 (1877) and subgenus *Dichone* Salisb. ex Bak. Handb. Irid. 190 (1892) are *Ixia* subgenus *Dichone* Lewis in J. S. Afr. Bot. **28**: 159 (1962).

Subgenus *Stenobasis* Bak. Handb. Irid. 196 (1892) is partly *Tritoniopsis* L. Bol. and partly *Zygotritonia* Mildbr.

Section *Stenobasis* (Bak.) Diels in Pfl. Fam. ed. 2, **15a**: 490 (1930) is *Tritoniopsis* L. Bol.

SPECIES EXCLUDED

Montbretia abyssinica Hochst. in Flora **24**: 1 (1841) [*Tritonia abyssinica* (Hochst.) Walpers, Ann. Bot. Syst. **3**: 613 (1852-53)]. Type: *Schimper Pl. Abyss.* 329: The isotype in G is a species of *Geissorhiza* (*G. ?abyssinica* R. Br. ex. Walp. p. 614) and not a *Lapeyrousia* as indicated by Baker (1877).

T. acroloba Harms in Bot. Jb. **30**: 278 (1902) is *Radinosiphon leptostachys* (Bak.) N.E.Br. in Trans. Roy. Soc. S. Afr. **20**: 263 (1932).

Montbretia aequimaculata Heynh. Nom. Bot. Hort. **2**: 417 (1846) nom. nud. Identity not known.

T. anigozanthiflora Sweet, Hort. Brit. ed. 1. **398** (1827) nom. nud. (*Montbretia anigozanthaeiflora* (Sweet) Heynh. *ibid.*, nom. nud.). Identity not known.

T. aurea Pappe ex Hook. in Curtis's bot. Mag. **73** t. 4335 (1847) is *Crocasmia aurea* (Pappe ex Hook.) Planch. Fl. Serres Ser. 1, **7**: 161 (1851-52).

T. bongensis Pax in Bot. Jb. **15**: 153 (1893) is *Zygotritonia bongensis* (Pax) Mildbr. in Bot. Jb. **58**: 230 (1923).

T. carnea Hort., Pasq. Cat. Orto Bot. Nap. 104 (1867), nom. nud. Identity not known.

T. cinnabarina Pax in Bot. Jb. **15**: 152 (1893) is *Crocasmia cinnabarina* (Pax) De Vos, comb. nov. Type: Angola, Catala Canginga, *Teucsz in Exped. A. v. Mechow* 573 (B, holo-).

T. concolor Sweet, Hort. Brit. ed. 1. **398**: (1827) [*Montbretia concolor* (Sweet) Voigt, Hort. Suburb. Calc. 611 (1845)] is *Ixia paniculata* Delaroche, Descr. Pl. aliq. nov. 26, t. 1 (1766), fide Lewis (1962).

T. cooperi Bak. Handb. Irid. 192 (1892) nom. illeg., non Klatt (1882) is *Watsonia cooperi* (Bak.) L. Bol. in J. Bot. Lond. **67**: 135 (1929). See also Lewis (1941).

T. crocosmiflora Nich. Dict. Gard. **4**: 94 (1888), a garden hybrid, is *Crocasmia crocosmiflora* (Nich.) N.E.Br. in Trans. Roy. Soc. S. Afr. **20**: 264 (1932).

T. fucata Lindl. in Bot. Reg. **24** t. 35 (1838) [*Montbretia fucata* (Lindl.)

Voigt, Hort. Suburb. Calc. 611 (1845)] is *Chasmanthe fucata* (Lindl.) N.E.Br. in Trans. Roy. Soc. S. Afr. **20**: 274 (1932).

Montbretia gallabatensis Schweinf. ex. Bak. in J. Linn. Soc. **16**: 155 (1877) is *Lapeirousia abyssinica* (Hochst.) Bak. *ibid.*

T. graminifolia Bak. Handb. Irid. 195 (1892) is *Anomatheca grandiflora* Bak. in J. Bot. Lond. **14**: 337 (1876), according to W. Marais' determination of the type in K.

T. latifolia (Delar.) N.E.Br. in Kew Bull. **1929**: 135 (1929) is *Ixia latifolia* Delar. Descr. pl. aliq. nov. 22 (1766), *fide* Lewis (1962).

T. longiflora (Ker) Ker-Gawl. in Kon. & Sims, Ann. Bot. **1**: 228 (1805), non N.E.Br. (1928) is *Ixia paniculata* Delaroche Descr. pl. aliq. nov. 26 (1766).

T. macowanii Hort., cf. Gard. Chron. **2**: 374, 407 (1877), an orthographic error for *Tritoma macowanii*, is *Kniphofia triangularis* Kunth, Enum. Pl. **4**: 551 (1843). See Codd in Bothalia **9**: 469.

T. masonorum L. Bol. in Ann. Bol. Herb. **4**: 43 (1926) is *Crocasmia masonorum* (L. Bol.) N.E.Br. in Trans. Roy. Soc. S. Afr. **20**: 264 (1932).

T. mathewsiana L. Bol. in Ann. Bol. Herb. **3**: 76 (1923) is *Crocasmia mathewsiana* (L. Bol.) Goldbl. in Jl S. Afr. Bot. **37**: 423 (1971).

T. mensensis Schweinf. in Bull. Herb. Boiss. **2**, App. ii: 86 (1894) is a species of *Gladiolus*. Type: Eritrea: Gheleb in prov. Mensa, Schweinfurth 1188 (K).

T. media cf. Pritz. Ic. Ind. **1**: 1124, an orthographic error for *Tritoma media* Ker-Gawl. which is *Kniphofia sarmentosa* (Andr.) Kunth, Enum. Pl. **4**: 552 (1843). See Codd in Bothalia **9**: 453.

T. nervosa (Bak.) Klatt in Abh. naturf. Ges. Halle **15**: 358 (1882) is *Tritoniopsis nervosa* (Bak.) Lewis in Jl S. Afr. Bot. **25**: 351 (1959).

T. nervosa Bak. in Bull. Herb. Boiss. Ser. 2, **1**: 864 (1901) nom. illeg., non Klatt (1882), is e. descr. a *Tritoniopsis* sp., cf. *T. ramosa* Eckl. ex Klatt var. *unguiculata* (Bak.) Lewis in Jl S. Afr. Bot. **25**: 329 (1959).

T. odorata Lodd. Bot. Cab. **19** t. 1820 (1832), nom. nud. is *Freesia corymbosa* (Burm. f.) N.E.Br. in Kew Bull. **1929**: 132 (1929).

T. paniculata (Delaroche) Klatt in Abh. naturf. Ges. Halle **15**: 358 (1882) is *Ixia paniculata* Delaroche. Descr. pl. aliq. nov. 26 (1766), fide Lewis (1962).

T. pauciflora (Bak.) Klatt in Abh. naturf. Ges. Halle **15**: 358 (1882) [*Montbretia pauciflora* Bak. in J. Bot. Lond. **14**: 336 (1876)] is *Gladiolus floribundus* Jacq. Coll **4**: 162 (1792), f. Lewis e.a. (1972).

T. pauciflora Bak. Handb. Irid. 193 (1892), non (Bak.) Klatt (1882), is *Hesperantha pauciflora* (Bak.) Lewis in Flow. Pl. S. Afr. **18** t. 682 (1938).

T. pottsii (Bak.) Bak. in Curtis's bot. Mag. 109 t. 6722 (1883) is *Crocsmia pottsii* (Bak.) N.E.Br. in Trans. Roy. Soc. S. Afr. **20**: 264 (1932).

T. quinquenervata Foster in Contr. Gray Herb. **114**: 46 (1936) is *Watsonia cooperi* (Bak.) L. Bol. in J. Bot. Lond. **67**: 135 (1929). See also Lewis (1941).

T. reflexa Klatt ined. in herb. is *Ixia scillaris* L.

T. refracta (Jacq.) Ker-Gawl. in Kon. & Sims. Ann. Bot. **1**: 228 (1805) is *Freesia refracta* (Jacq.) Klatt in Linnaea **34**: 673 (1865–66), f. Goldblatt (1982).

T. riparia Cordemoy. Fl. l'Ile Réunion 161 (1895) is possibly a species of *Dietes*. The isotype in P has fruits only.

T. rocheana Sweet. Hort. Brit. 398 (1827) [*M. rocheana* Heynh. Nom. Bot. Hort. **2**: 418 (1846)] is *Ixia bellendenii* Foster in Contr. Gray Herb. **114**: 47 (1936).

T. rochensis Ker-Gawl. in Curtis's bot. Mag. **37** t. 1503 (1812) is *Ixia bellendenii* Foster ibid. cf. Lewis (1962).

T. schimperi Aschers. & Klatt in Linnaea **34**: 697 (1865–66) is *Lapeirousia schimperi* (Aschers. & Klatt) M. Redh. in Kew Bull. **34**: 307. Type: *Schimper* Pl. Abyss. 2304 (G, iso-).

T. schlechteri Bak. in Bull. Herb. Boiss. Ser. 2. **4**: 1005 (1904) is a

species of *Ixia*, cf. *I. orientalis* L. Bol. Type: Cape, Swarteberg, *Schlechter* 5609 (Z, holo-).

T. scillaris (L.) Bak. in J. Linn. Soc. **16**: 163 (1877) is *Ixia scillaris* L. Sp. Pl. ed. 2, **1**: 52 (1762), fide Lewis (1962).

T. striata (Jacq.) Ker-Gawl. in Kon. & Sims, Ann. Bot. **1**: 228 (1805), non Klatt 1895, [*Montbretia striata* (Jacq.) Voigt, Hort. Suburb. Calc. 610 (1845)] is *Babiana striata* (Jacq.) Lewis in Jl S. Afr. Bot. **7**: 55 (1941).

T. templemannii Bak. Handb. Irid. 193 (1892) is *Pillansia templemannii* (Bak.) L. Bol. in Ann. Bot. Herb. **1**: 20 (1915).

T. tenuiflora (Vahl) Ker-Gawl. in Curtis's bot. Mag. **31** sub t. 1275 (1810) [*Montbretia tenuiflora* (Ker-Gawl.) Voigt, Hort. suburb. Calc. 611 (1845)] is *Ixia paniculata* Delaroche, Descr. pl. aliq. nov. 26, t. 1 (1766), fide G. J. Lewis (1962).

T. teretifolia Bak. Handb. Irid. 194 (1892) is *Gladiolus permeabilis* Delar. Descr. pl. aliq. nov. 27, t. 2 (1766) ssp. *wilsonii* (Bak.) Lewis e.a. (1972).

T. thunbergii N.E.Br. in Kew Bull. **1929**: 137 (1929) is *Ixia erubescens* Goldbl. in Jl S. Afr. Bot. **37**: 233 (1971).

T. tigrina Pax in Bot. Jb. **15**: 152 (1893) is possibly a species of *Schizostylis*. From Angola. Type in B.

T. trinervata Bak. Handb. Irid. 191 (1892) is *Ixia trinervata* (Bak.) Lewis in Jl S. Afr. Bot. **28**: 169 (1962).

T. tristis Dehnh. Cat. horti Camald. ed. 2, 24 (1832) is, e descr., not *Tritonia*. Type not found.

T. undulata sensu Bak. in J. Linn. Soc. **16**: 163 (1877) in part, non N.E.Br., is *Ixia erubescens* Goldbl. in Jl S. Afr. Bot. **37**: 233 (1971).

T. unguiculata Bak. Handb. Irid. 196 (1892) is *Tritoniopsis ramosa* Eckl. ex Klatt var. *unguiculata* (Bak.) Lewis in Jl S. Afr. Bot. **25**: 329 (1959).

T. ventricosa Pasq. Cat. Orto Bot. Nap. 104 (1867) nom. nud. Identity not known.

T. ventricosa Bak. Handb. Irid. 193 (1892) is *Gladiolus brevitubus* Lewis in JI S. Afr. Bot. Suppl. 10: 171 (1972), a nom. nov. for *T. ventricosa* Bak.

T. viridis (Ait.) Ker-Gawl. in Kon. & Sims, Ann. Bot. 1: 231 (1805) [*Montbretia viridis* (Ker-Gawl.). Voigt, Hort. suburb. Calc. 610 (1845)] is *Anomatheca viridis* (Ait.) Goldbl. in JI S. Afr. Bot. 37: 443 (1971).

T. watsonioides Bak. Handb. Irid. 195 (1892) is *Watsonia watsonioides* (Bak.) Oberm. in Bothalia 8: 115 (1962).

T. wilsonii Bak. in Gard. Chron. 26: 38 (1886) is *Gladiolus permeabilis* Delar. ssp. *wilsonii* (Bak.) Lewis in JI S. Afr. Bot. Suppl. 10: 133 (1972).

T. xanthospila Ker-Gawl. ex Spreng. Syst. Veg. 1: 154 (1825) [*Montbretia xanthospila* Heynh. Nom. Bot. Hort 2: 418 (1846)] is *Freesia xanthospila* Klatt in Linnaea 34: 673 (1865–66), a species based on cultivated material, f. Goldblatt in JI S. Afr. Bot. 48: 89 (1982).

ADDENDUM: NOTE ON A SPECIES ALREADY REVISED IN PART 1

***Tritonia tugwelliae* L. Bol.**

The following more detailed description is given of the flowers from a collection, *De Vos 2463*, found in 1981, east-north-east of Laingsburg along the N1 national road (Ladismith 3321-AA), that flowered in August 1982.

Perianth tube with red lines inside; *segments* (except the median posticous) with red lines in the throat; median anticous also with a yellow zone in the throat above which a small red spot occurs. *Stamens* and *style* curved against the posticous segment; *anthers* at first violet, pollen violet or mauve. *Stigmas* small, terminal.

The newly opened flowers have the median posticous perianth segment porrect and the other segments spreading or recurved. In older flowers, the three anticous segments fold upwards over one another, partially closing the throat of the flower; the three posticous segments are strongly reflexed, also folding over one another at the posterior side of the flower. **Fig. 30.**

ACKNOWLEDGEMENTS

My grateful thanks are due to the directors and curators of the herbaria mentioned in this work, from whom specimens of *Tritonia*, including type specimens, were obtained for examination; to the many people who helped in collecting fresh material from their natural habitats; and lastly, to the head of the Department of Botany of the University of Stellenbosch for facilities to work in the Department after my retirement.

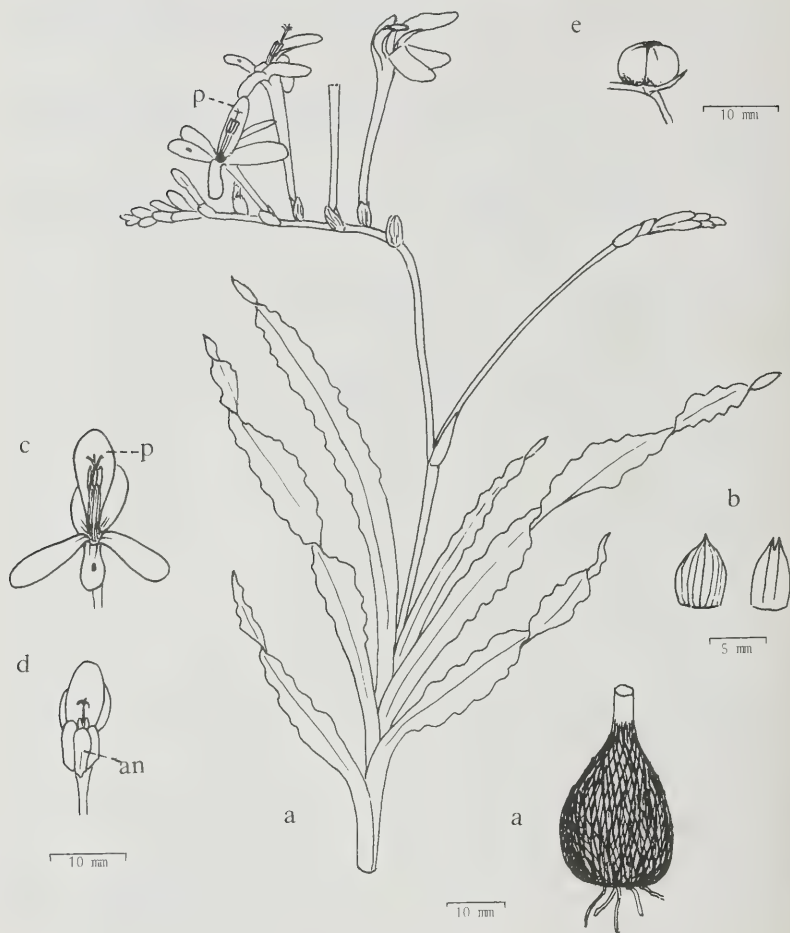


FIG. 30

Tritonia tugwelliae (De Vos 2463): a, plant; b, outer (left) and inner (right) bract; c, newly opened flower; d, older flower; e, capsule; an, median anticous perianth segment; p, posticous segment.

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SIX MORE NEW SPECIES OF *LACHENALIA* (LILIACEAE)

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ABSTRACT

Six new species of *Lachenalia* are described, and the characters of the ripe seeds are used as additional diagnostic features in the genus.

UITTREKSEL

'N VERDERE SES NUWE *LACHENALIA*-SOORTE (LILIACEAE)

Ses nuwe *Lachenalia*-soorte word beskryf en die eienskappe van die ryp sade word as aanvullende onderskeidende kenmerke in die genus voorgestel.

Key words: *Lachenalia*, sp. nov., Liliaceae, South Africa, seed, diagnostic characters.

INTRODUCTION

The six new species described all have seeds with terminal ridged arils of various lengths. Three of the species, *L. zebrina*, *L. nordenstamii* and *L. whitehillensis*, have a number of features in common, such as the single banded leaf, campanulate flowers with exerted stamens, and in the case of the two former the seeds are the largest in the genus, with medium-length terminal ridged arils and extruded micropyles. In *L. ameliae* the seed is very small, with a medium ridged aril, the flowers are urceolate and the leaves often have an integument of hairs on the upper surface. *L. giessii* and *L. moniliformis* have seeds which are very small with an almost obsolete terminal ridged aril. *L. giessii* is confined to the south western area of South West Africa/Namibia, while *L. moniliformis* is unique in having many filiform leaves with a beaded appearance, and is only known from the type locality near Worcester, where it was discovered as recently as 1978.

Accepted for publication 17th June, 1983



FIG. 1.

Lachenalia zebrina: 1. Outer perianth segment and stamen; 2. Inner perianth segment; 3. Gynaecium; 4. Ripe capsule; 5. Capsule from above; 6. Seed (*Compton 3536*).

Lachenalia zebrina Barker, sp. nov.; folio solitario, conduplicato vel canaliculato, falcato vel lanceolato, supra glauco, subter fasciato marronino, basi amplexi atropurpurenti, distinguitur.

Inflorescentia racemosa; pedicelli longi vel breves, patentes. *Flores* cernui, curti campanulati, basim truncatam; segmenta externa ovalia, eburnea suffusa viridia vel brunnea, apices recurvatos; segmenta interiora leviter longiora vel segmenta externa; stamina manifeste exerta. *Capsula* grandis, inflata, oboviodea. *Semen* magnum, elongatum, plerumque curvatum; arillus porcatus, terminalis; micropyle manifeste exertus, porcatus, arillum aequantes.

Type Material: Cape Province—3320 (Montagu): Karoo Garden, Whitehill (-BA), 17/9/1945, *Compton 17392* (NBG, holo., BOL, iso.).

Plant up to 300 mm, usually less. *Bulb* globose to obovoid 10–30 mm diam.; outer tunics often spongy, light brown. *Leaf* one, blade 60–220 mm long, 20–60 mm broad, falcate to lanceolate, conduplicate or channelled, glaucous green above, banded with maroon below, margin often undulate, clasping base, silvery-white with maroon bands above shading to magenta at base. *Inflorescence* racemose, 60–105 mm long, 20–60 mm diam., few- to many-flowered, lax to dense, pedicels 2–20 mm long, often shorter toward the base, spreading, flowers cernuous, bracts minute, membranous, narrow lanceolate. *Flowers* small, cream tinged with green or brown, 4–6 mm long, tube a flat disc 2 mm diam.; outer segments 4–6 mm long, oblong with apex recurved; inner segments slightly longer, narrower with recurved apex; stamens cream, well exerted, up to 8 mm long; ovary ovoid 1–2 mm diam., green; style 4–8 mm long. *Capsule* membranous, globose to obovoid up to

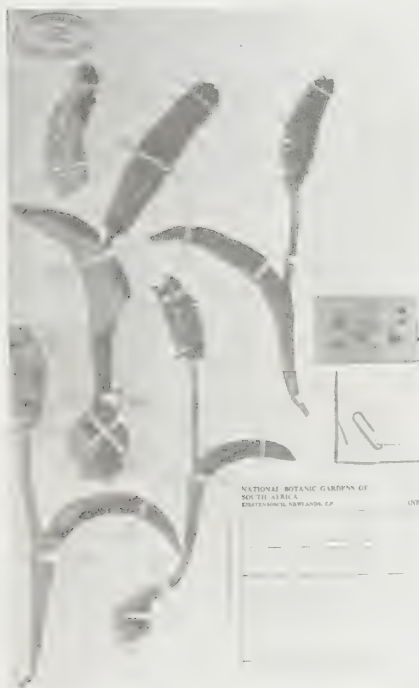


FIG. 2.

Lachenalia zebrina: forma *densiflora* (Thomas s.n. sub NGB 105714).

10 mm diam., winged; seeds large, elongate, curved, aril ridged, terminal, medium length, micropyle extruded, ridged, as long as aril.

DIAGNOSTIC CHARACTERS

Lachenalia zebrina is characterised by its single, usually falcate, conduplicate or channelled, banded leaf which is glaucous green above; by its racemose inflorescence; and flowers which are truncate at the base; with the tube reduced to a small flat disc; by its large, inflated capsule, which is one



FIG. 3.

Lachenalia zebrina: 1. Seed side view; 2. Seed from above; 3. Seed from below (Compton 21939).

of the largest in the genus; and its comparatively large curved seed, with a medium length ridged aril and an extruded ridged micropyle of equal length.

Lachenalia zebrina Barker, sp. nov. forma **densiflora** Barker forma nov.; a forma typica, inflorescentia densa, pedicellis brevibus et floribus patentibus, differt.

Type Material: Cape Province—3119 (Calvinia): 23 mls N of Downes on Klipwerf road (-BD), 2/10/1974, *Thomas s.n.* sub NBG 105714 (NBG, holo.).

It differs from the typical form in its more numerous flowers with short pedicels, forming a dense narrow inflorescence.

It is not possible to separate forma *densiflora* geographically on its distribution pattern, but it is such a variable species that it is considered useful to designate the two extremes of the graduated sequence.

Specimens of *Lachenalia zebrina* have previously been included in the species *Lachenalia anguinea* Sweet, and in 1930 it was mistakenly illustrated under that name, in the *Journal of The Botanical Society* XVI Plate II pp. 10–12. However, recently, when a study was made of the capsules and ripe seeds of the two taxa, it was found that the plants which occur in the coastal

areas of the western Cape, had a small obovoid capsule containing very small, ovoid seeds with a minute ridged, terminal aril, and the flowers had a distinct tube which narrowed towards the base. The capsules of the plants occurring in the Karoo areas were very large, inflated and globose, and the seeds were very much larger, elongated, curved, with a ridged terminal aril of medium length, and an exstruded, ridged micropyle of about the same length as the aril, while the perianth was truncate at the base.

These taxa are now considered to represent two distinct species, separated geographically. The plants from the sandy coastal areas of the western Cape, extending from Piketberg in the south to the Richtersveld in the north, agree with Sweet's illustration in Sweet's *British Flower Garden* I t. 179 (1838), which represents the iconotype of *L. anguinea* Sweet. The laid-out flower is depicted with a distinct tube.

The plants, which are widely distributed in the Karoo from Matjiesfontein in the south, to the Knersvlakte in the Vanrhynsdorp district in the north, and eastwards to the Carnarvon, Williston, and Sutherland districts, are extremely variable in the width of the leaves and the shape of the inflorescence, but are all grouped under the new name *Lachenalia zebrina*.

In the typical form the inflorescence is very lax with long pedicels to the flowers, which are cernuous; in forma *densiflora* the flowers are much more numerous and congested, with comparatively short pedicels and the flowers are spreading, producing a dense, narrow elongated head, which gives the plant a distinctive appearance. However, intermediate variations occur which connect the two extremes.

The specific name was suggested by the resemblance of the striped, falcate leaf to the hind leg of a zebra.

L. zebrina Barker forma *zebrina*

SPECIMENS EXAMINED

CAPE PROVINCE—3022 (Carnarvon): Carnarvon (-CC), *Pillans s.n.* Hort. NBG 3740/14 (BOL).

—3118 (Vanrhynsdorp): Farm Klipdrift, Knersvlakte (-B), 22/9/1970, *Hall* 3620 (NBG).

—3119 (Calvinia): Brandkop, NE of Nieuwoudtville (-AA), 13/9/1961, *Barker* 9484 (NBG); Near Kokerboomkop 16 mls S of Loeriesfontein (-AB), 27/9/1952, *Lewis* 2517 sub SAM 61824 (BOL, K. SAM); Between Loeriesfontein and Nieuwoudtville, 27/9/1952, *Johnson* 604 (NBG); Gannabos junction with Loeriesfontein road, 2/10/1974, *Thomas s.n.* sub NBG 105717 (NBG); NE of Nieuwoudtville on Kleindoring road (-AD), 28/9/1970, *Barker* 10765 (NBG); 30 mls NW of Calvinia (-BC), 29/10/1970, *Stayner s.n.* sub NBG 93033 (NBG); Calvinia (-BD), Sept 1914, *Macpherson s.n.* sub Hort. NBG 3693/14 (BOL); Calvinia, 1/10/1940, *Barker* 853 (NBG). —3120 (Williston): Farm Langfontein SE of Calvinia (-CA), 25/8/1975, *Hall* 4259 (NBG); Visagiesrus near Calvinia (-DA), 8/1956, *Acocks* 18894 (PRE); 39 mls SW of Williston (-D), 24/9/1954, *Acocks* 17710 (PRE).

—3121 (Fraserburg): Between Fraserburg and Carnarvon (-D), 20/9/1938, *Hafström and Acocks* 222 (PRE); 42 km W of Loxton (-DC) 29/9/1974, *Nordenstam and Lundgren* 2090 (S).

—3219 (Wuppertal): Elands Vlei, Lower Tanqua (-BC), 8/9/1921, *Marloth s.n.* sub 10461 (PRE); Gemsbokfontein, Ceres Karoo (-DB), 15/9/1973, *Hanekom* 2149 (PRE).

—3220 (Sutherland): Foot of Gannagas Pass (-AA), 29/9/1968, *Stayner s.n.* sub NBG 93587 (NBG); Top of Gannagas Pass, 29/9/1968, *Stayner s.n.* sub NBG 93586 (NBG); Hout Hoek (-CA), 13/9/1971, *Hanekom* 1574 (PRE).

—3320 (Montagu): Patats Rivier, Ceres, Karoo (-AB), 2/10/1954, *Esterhuysen* 23535 (NBG, BOL, K, PRE); Whitehill Ridge (-BA), 26/9/1926, *Compton* 3137 (BOL); Karoo Garden, Whitehill, 24/9/1929, *Compton* 3536 (BOL, NBG), 12/10/1930, *Compton s.n.* sub BOL 21939 (BOL, NBG), 22/9/1941, *Barker* 1093 (NBG), 23/10/1943, *Compton* 15240 (NBG), 17/9/1945, *Compton* 17392 (BOL, iso.; NBG, holo.); Whitehill, 20/9/1943, *Compton* 14843 (NBG); Whitehill, 18/10/1928, *J. Gillett* 1712 (STE); 2 mls NE of Matjiesfontein, 3/10/1974 (young fruit), 16/8/1976 (flowers), *S. Olivier s.n.* sub NBG 105718 (NBG); Skeiding 7 mls beyond Matjiesfontein, 10/10/1954 (fruiting), *Isaac s.n.* sub NBG 71842 (NBG); 5 km E of Matjiesfontein, 28/9/1974, *Nordenstam and Lundgren* 2080 (S).

L. zebrina Barker forma *densiflora* Barker

SPECIMENS EXAMINED

CAPE PROVINCE—3119 (Calvinia): Near Soetwater at crossroads to Botterkloof (-AD), 1/10/1973, *Barker* 10891 (NBG); 23 mls N of Downes on Klipwerf Road (-BD), 2/10/1974, *Thomas s.n.* sub NBG 105714 (NBG, holo.); Road from Farm Kleinbrak to Middlepos (-DD), 28/9/1971, *Hiemstra s.n.* sub Hort. NBG 903/1971 (NBG).

—3120 (Williston): 20 mls E of Calvinia on Brandvlei road (-AC), 27/10/1970, *Thomas s. n.* sub NBG 93871 (NBG).

Lachenalia nordenstamii Barker, sp. nov.; habitu nano, bulbo multi-tunicato, strato extimo spongioso et strato intimo fibris membranis fissis, distinguatur.

Folium solitarium, lanceolatum-falcatum, canaliculatum; supra glaucum, subter fasciato vel maculato marronino. *Pedunculus* brevis valde gracilis. *Inflorescentia* racemosa, paucifloribus. *Flores* pusilli, cernui, late campanulati; tubus brevis; segmenta aequalia, bruneola, stria media marronina; apices recurvatos. *Stamina* valde exerta; filamenta crassa, marronina patentia. *Cap-sula* grandis, obovata vel cordata, alata. *Semen* elongatum vel rectum, interdum, curvatum; arillus porcatus micropyle exertus, porcatus, arillum aequans.

Type Material: Cape Province—2816 (Oranjemund): Numees Mts. (N of Hellskloof) Richtersveld, Namaqualand (-BD), bulbs collected 3/11/1962, flowered in cultivation 31/5/1963, *B. Nordenstam* 1739 (NBG, holo. of flowering plant); Mountain between Numees and Hellskloof, Richtersveld, Namaqualand, 4/11/1962, *B. Nordenstam* 1762 (NBG, holo. of capsules and seeds).

Plant dwarf 50–120 mm high. *Bulb* up to 20 mm diam., globose to ovate, covered with many layers of spongy tunics, produced into a neck up to 40 mm long, composed of many tunics, the inner ones split into narrow membranous fibres. *Leaf* one, 20–40 mm long, lanceolate, falcate, canaliculate, glaucous green, banded on the clasping base and lower surface with maroon bands, sometimes merging into spots towards the apex. *Peduncle* very slender, tinged with maroon, up to 25 mm long above the neck. *Inflorescence* racemose, few-flowered; bracts minute, narrow-lanceolate, membranous; pedicels short, 2–3 mm long, spreading to decurved. *Flowers* small, cernuous, widely campanulate, tube short, segments almost equal in length, 4–5 mm long, brownish with a central maroon stripe, apices recurved; stamens well exserted, up to 10 mm long, filaments comparatively stout, maroon, widely spread; style slender finally longer than the stamens. *Capsule* broadly obovate to obcordate, winged, up to 12 mm diam., 5–6 mm long, purplish; seeds large 3–3.5 mm long, 1–1.5 mm diam., usually straight, occasionally curved, aril ridged, medium, terminal, micropyle ridged, exstruded, as long as the aril.

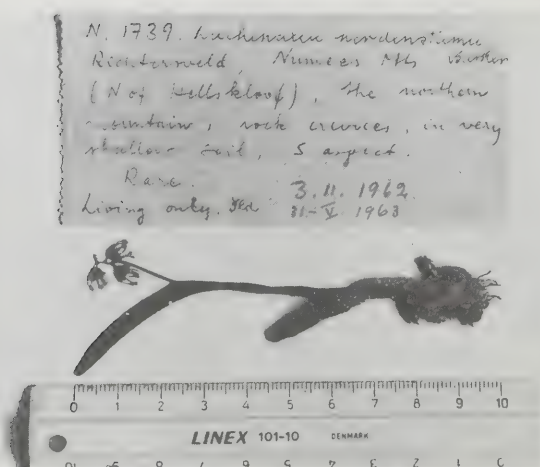
DIAGNOSTIC CHARACTERS

Lachenalia nordenstamii is distinguished by its dwarf habit, the long fibrous neck to the bulb, its single lanceolate, falcate canaliculate, banded leaf, its few-flowered racemose inflorescence, in which the short pedicels are spreading to decurved, its cernuous short widely campanulate flowers, with the stamens twice the length of the perianth, and the stout maroon filaments spreading widely. The seeds are some of the largest in the genus, distinctly longer than broad, usually straight, with a ridged aril of medium length, and an exstruded micropyle of equal length.

Two collections of bulbs of this very dwarf species were made by Dr. Bertil Nordenstam in the Richtersveld in November 1962. One of the collections was in fruit, and the capsules were preserved, and now represent the type specimens of the fruiting stage of the species. Bulbs of the second collection were grown in a pot at the Compton Herbarium, and one of these flowered on 31 May 1963. This flowering specimen was preserved and now represents the type of the species. Fortunately photographs were taken to supplement the material by Professor H. B. Rycroft, in both black and white, and colour, and these have aided considerably in describing the species. Two of these photographs are represented here.

In a recent consignment of *Lachenalia* specimens received on loan from Munich for identification, two good sheets of this species, one of flowering specimens and the other in the fruiting stage, were included. They were collected in 1977 in the south western corner of South West Africa/Namibia,

a



b



c



FIG. 4. a, b, c.

Lachenalia nordenstamii: a. Whole plant; b. Three plants (Nordenstam 1739);
 c. Capsules, seeds and old perianths (Nordenstam 1762).



FIG. 5.

Lachenalia nordenstamii: 1. Seed side view; 2. Seed from above; 3. Seed from below (Nordenstam 1762).

across the Orange River, north of the Richtersveld. They had been identified as *Lachenalia buchubergensis* Dinter, which has a similar leaf, and occurs in the same area; however in *L. buchubergensis* the flower is very distinct, it has a narrow cylindrical, sessile flower, with the stamens just emerging from the narrow mouth of the flower. The Zürich specimens are the first of *L. nordenstamii* to be recorded from SWA/Namibia, and they indicate that its distribution should be further investigated.

Lachenalia nordenstamii is closely allied to *Lachenalia zebrina* Barker sp. nov., but the latter is a much taller plant, without the fibrous neck to the bulb, the inflorescence is many-flowered and the flowers are narrowly campanulate, with slender declinate filaments. The seeds in both species are of a similar pattern, but in *L. zebrina* they are shorter and usually curved.

The distribution of the two species does not appear to overlap, as *L. nordenstamii*, as far as is known, occurs in the northern area of the Richtersveld and the southern part of SWA/Namibia, while *L. zebrina* is widespread, occurring in many parts of the Karoo. The most north westerly record of it available at present, is a collection made by Mr. H. Hall on the farm Klipdrift on the Knersvlakte, in the Vanrhynsdorp district.

The species is named in honour of Dr. Bertil Nordenstam who has done so much valuable work on the South African Flora, including some members of the Liliaceae.

SPECIMENS EXAMINED

SOUTH WEST AFRICA/NAMIBIA—2716 (Witputs): Aurus Mountain, South West Africa (-CA), 31.7.1977 (flowering), M. Müller 744 (M); Rosh Pinah und

Umgebung, Distrikt Lüderitz-Süd, South West Africa (-DD), 29/9/1977 (fruiting), *H. Merxmüller and W. Giess 32356* (M,W?).

CAPE PROVINCE—2816 (Oranjemund): Numees Mts (N of Hellskloof) Richtersveld, Namaqualand (-BD), bulbs collected 3/11/1962, flowered in cultivation 31/5/1963, *B. Nordenstam 1739* (NBG, holo. of flowering plant); Mountain between Numees and Hellskloof, Richtersveld, Namaqualand 4/11/1962, *B. Nordenstam 1762* (NBG, holo. of capsules and seeds).

Lachenalia whitehillensis Barker, sp. nov.; folio solitario, conduplicato, angusto-lanceolato vel lineari, supra veneto subter maculato vel fasciato marronino basi amplecti atropurpurenti, distinguitur.

Inflorescentia racemosa, angusta; pedicelli curti; flores cernui vel patent-es. *Flores* margaritacei vel opalescentes, campanulati, basim truncatam; segmenta interiora longiora vel segmenta externa; segmenta laterale imbricata. *Stamina* manifeste exerta. *Semen* oviodeum; arillus porcatus terminalis.

Type Material: Cape Province—3320 (Montagu): Whitehill Laingsburg Division (-BA), 20/9/1943, *Compton 14845* (NBG, holo.).

Plant up to 360 mm high. *Bulb* globose, up to 20 mm diam.; outer tunics membranous, brown. *Leaf* 1, blade narrow-lanceolate, conduplicate, up to 120 mm long, 15 mm wide blue-green, spotted or banded with maroon on lower surface, clasping base up to 80 mm long, spotted or banded with maroon shading to magenta toward the base. *Peduncle* slender, up to 140 mm long, banded or spotted with maroon. *Inflorescence* racemose, few- to many-flowered up to 160 mm long, 20–30 mm diam.; rachis spotted with maroon; flowers campanulate, truncate at base, spreading or slightly cernuous, scented; pedicels up to 3 mm long. *Perianth* up to 7 mm long, 4 mm diam. at base; tube 1 mm long; outer segments ovate, up to 4 mm long, pale blue at base, cream above with pale red-brown gibbositities; inner segments 6 mm long, obovate-obtuse, cream with pale blue keel and a brownish spot near the apex; two lateral segments overlapping and concave; stamens exerted up to 10 mm long; ovary ovate, pale green; style up to 10 mm long. *Capsule* membranous, obovate, 7 mm long; seed ovoid, aril ridged, terminal, medium length.

DIAGNOSTIC CHARACTERS

Lachenalia whitehillensis is characterised by its single linear to narrow-lanceolate, conduplicate leaf which is spotted or banded on the lower surface and on the clasping base. Inflorescence racemose, narrow, short pedicels. The pale campanulate flowers are truncate at the base, the inner segments longer than the outer, and the two lateral inner ones overlapping and concave. The stamens are well exerted and the ovoid seeds have a ridged terminal aril.

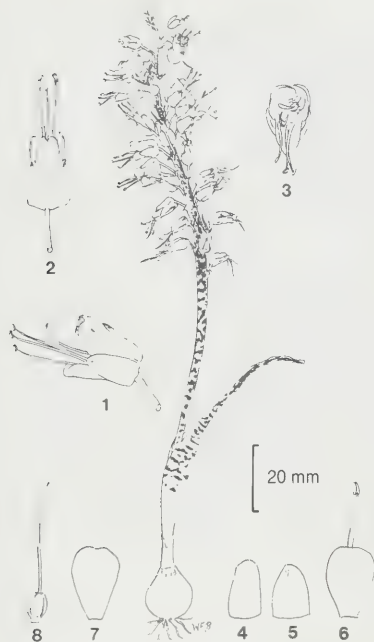


FIG. 6.

Lachenalia whitehillensis: 1. Flower side view; 2. Flower from below; 3. Flower front view; 4. Upper outer perianth segment; 5. Lateral outer perianth segment; 6. Lateral inner perianth segment and stamen; 7. Lower inner perianth segment; 8. Gynaecium (Compton 14845).

Lachenalia whitehillensis superficially resembles *L. zebrina* which occurs in the same area in the type locality, but it differs from it in the shape and colouring of the flowers, in its narrow inflorescence, and markedly in the shape of the seed which in *L. zebrina* is elongate and one of the largest in the genus.

The species has been named after the original site of the Karoo Garden near Whitehill Station, where it was collected a number of times in the sandy river silt along the banks of the Bavians River. An earlier collection by R. Marloth made in 1920 and a recent one by W. J. Hanekom, both from the Sutherland Division, indicate that it has a much wider distribution range to be investigated.

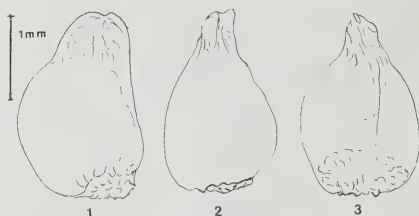


FIG. 7.

Lachenalia whitehillensis: 1. Seed side view; 2. Seed from above; 3. Seed from below (Barker 1094).

SPECIMENS EXAMINED

CAPE PROVINCE—3220 (Sutherland): Farm Uitkyk Valley, Roggeveld (-AD), Oct. 1920, *Marloth* 9712 (PRE); Hout Hoek, Sutherland (-CA), 13/9/1971, *Hanekom* 1574 (PRE).

—3320 (Montagu): Tweedside (-AB), 25/9/1931, *Compton* 3960 (BOL), 28/9/1951, *Barker* 9175 (NBG); Whitehill, Laingsburg Division (-BA), 20/9/1943, *Compton* 14845 (NBG, holo.), 21/9/1943, *Barker* 1094 (NBG); Karoo Garden, Whitehill, 17/9/1945, *Compton* 17394 (NBG); Karoo near Matjiesfontein, Oct. 1920, *Marloth* 9576 (PRE).

Lachenalia giessii Barker, sp. nov.; habitu nano bulbo tunicis multis brunis in collum productum, distinguitur.

Folia duo, variables, lineares vel lorata, flaccida, sine maculata. *Inflorescentia* racemosa; pedicelli patentes in longitudinem variables. *Flores* pusilli, pauci vel multi, albi; segmenta interiora leviter longiora vel segmenta externa; segmenta tota signis fuscatis prope apices. *Stamina* leviter exerta. *Semen* ovioideum, arillo minuto terminali, porcato.

Type Material: South West Africa/Namibia—2616 (Aus): Garub W of Aus, Lüderitz District (-CA) 1/9/1963, *H. Merxmüller and W. Giess* 3401 (M, iso.; PRE, iso.; WIND, holo.).

Plant 60–160 mm high, usually dwarf. *Bulb* ovate 10–30 mm diam., covered with many layers of brown tunics produced into a neck of fibres 20–50 mm long, the inner ones darker and cartilaginous, the outer becoming paler, softer and often spongy in texture; the membranous leafsheath is often longer than the neck fibres. *Leaves* 2, without markings, flaccid, and very variable in shape, from linear, conduplicate to lanceolate-lorate, 2–20 mm broad, suberect to spreading, longer than the peduncle. *Peduncle* usually shorter than the inflorescence. *Inflorescence* racemose, few to many-flowered, from 25–40 mm in diam.; pedicels spreading 2–12 mm long, elongating in the fruiting stage and spreading at right angles; bracts minute,

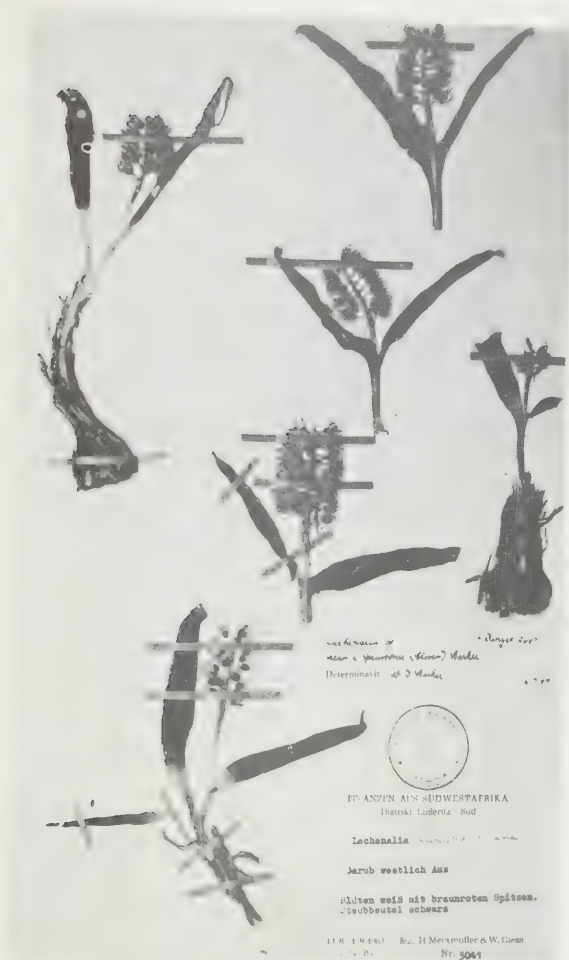


FIG. 8.

Lachenalia giessii: sheet in Botanical Research Institute, Pretoria (Merxmüller and Giess 3041, isotype).

lanceolate, membranous, white. Flowers 5–8 mm long, narrowly campanulate, tube white, 1.5 mm long, narrowing to the base; outer segments ovate-oblong, subacute, up to 6 mm long and 3 mm broad, white with reddish-purple



FIG. 9.

Lachenalia giessii: sheet in the Windhoek Herbarium (Giess Wind. 12845).

gibbositities; inner segments obovate, a little longer than the outer, white with a reddish-purple marking at the apex; stamens slightly exserted, spreading; ovary globose; style filiform, finally exserted. *Capsule* obovate, membranous with a few seeds in each loculus; seed globose, aril minutely ridged, almost obsolete.

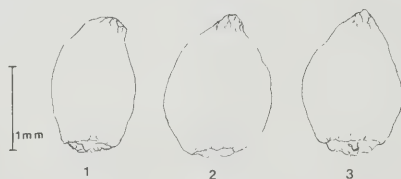


FIG. 10.

Lachenalia giessii: 1. Seed side view; 2. Seed from above; 3. Seed from below (Giess Wind. 14656).

DIAGNOSTIC CHARACTERS

Lachenalia giessii is a dwarf species with white campanulate flowers, reminiscent of some of the dwarf *Ornithogalum* species, but each segment has a distinct dark marking at the apex. The pedicels which are usually shorter than the flowers, often lengthen considerably in the fruiting stage, and the leaves which are flaccid and without markings, vary in shape from linear, conduplicate to lanceolate. The seed which is globose, belongs to the group with an almost obsolete aril.

The distribution of *Lachenalia giessii* appears to be confined to the south western corner of South West Africa/Namibia between latitudes 26°–28°. It has not been recorded south of the Orange River, although it has been found at Schakalberg (Jakhalsberg) near the northern bank. The earliest record was made by S. Karen Regius in 1941, south of Aus, and numerous collections have been made in the area since, mainly by Mr. W. Giess, recently retired Curator of the Windhoek Herbarium, some while on expeditions with Dr. Merxmüller of München, West Germany. The species is named in honour of Mr. W. Giess in recognition of the valuable work he has done in building up the Windhoek Herbarium collections.

It appears to be most closely allied to *L. pearsonii* (Glover) Barker, a more delicate plant, which is only known from the type collection, which was made by Professor H. W. Pearson on the Percy Sladen Memorial Expedition to the Great Karasberg, South West Africa, 1912–1913. Unfortunately, no living material has been available for study or comparison of either of the two species. The seeds of *L. pearsonii* are unknown. Its flowers are smaller and the segments are described as spreading from the base, and it flowers in January. In *L. giessii* the segments appear to be erect, and it is in flower during August and September.

SPECIMENS EXAMINED

- SOUTH WEST AFRICA/NAMIBIA—2616 (Aus): Farm Klein Aus, W of Aus, Lüderitz District (-CA), 9/8/1959, W. Giess and D. v. Vuuren 917 (M, PRE, WIND); Garub, W of Aus, Lüderitz-Süd, 1/9/1963, H. Merxmüller and W. Giess 3041 (M, iso.; PRE, iso.; WIND, holo.); South of Aus (-CB), Sept 1941, S. Karen Regius s.n. (Wind); North of Aus, 8/9/1973, W. Giess 12827 (M, PRE, WIND); Farm Augustfelde, 7/9/1973, W. Giess 12805 (M, PRE, WIND); Farm Kubub, 9/9/1973, W. Giess 12845 (M, PRE, WIND).
—2617 (Bethanien): Tirasberge, Bethany Dist. (-BA), 16/8/1963, H. Merxmüller and W. Giess 2857 (M, PRE, WIND).
—2716 (Witputs): Farm Witputz-Süd, Lüderitz District (DC), 24/9/1972, H. Merxmüller and W. Giess 28776 (M, PRE, WIND); Farm Spitzkop, 15/8/1976, W. Giess 14656 (M, PRE, WIND).
—2816 (Oranjemund): Schakal Mt. (-BA), 1/8/1977, M. Müller 781 (WIND).

Lachenalia moniliformis Barker, sp. nov.; bulbo parvo, producentibus stolone crassis multis, terminatis bulbilis carnosus, distinguatur.

Folia teretia viridia; usque ad octo; non amplexentia pedunculi basi. Folia singularia propter fascias circulares elevatas per superi duos longitudinis tries, monilia simulans; pars basalis fasciata vel maculata, marroninescens prope basin. *Inflorescentia* racemosa. *Flores* campanulati, pusilli, opalescens; segmenta interiora vix longiora vel segmenta externa. *Stamina* manifeste exerta. *Semen* ovoideum, arillo minuto terminalis porcato.

Type Material: Cape Province—3319 (Worcester): Lemoenpoort (-CD), 22/9/1978, P. L. Perry 795 (NBG, iso.), cultivated at Worcester Karoo Garden; 5/9/1979, P. L. Perry 795 (NBG, iso.), cultivated at Compton Herbarium; 6/9/1979, P. L. Perry 795 (NBG, holo.), collected in wild habitat.

Plant 120–170 mm high (up to 330 mm when cultivated). *Bulb* globose to depressed globose, 15 mm diam., covered with a few membranous, light-brown scales, producing many bulbils on long stout stolons from the base. *Leaves* many, up to 8, erect to spreading, shorter than the peduncle, 60–160 mm long (up to 250 mm when cultivated), filiform terete, green with circular raised fleshy bands along two-thirds of their length, giving them the appearance of strings of beads, lower third banded or spotted with dark maroon, shading to magenta at the base. *Peduncle* up to 90 mm long, very slender, green, finely and densely spotted with dark maroon. *Inflorescence* racemose, 20 mm diam. (25 mm in cultivated specimens), rachis 40–80 mm long (up to 110 mm in cultivated specimens), finely spotted with maroon; flowers lax, cernuous; bracts very small and narrow lanceolate, membranous; pedicels 3–5 mm long, white, spreading. *Flowers* 5–7 mm long, 4 mm diam., truncate at the base, campanulate, tube very short, very pale blue; outer segments narrow oblong, 4–6 mm long, extreme apex recurved, very pale blue at base, shading to pale pink with reddish-brown gibbosities; inner segments only slightly longer than outer, obovate, apex subacute, recurved, white with reddish-brown markings near apex; stamens up to 11 mm long, well exerted; filaments white; ovary green, obovate, 2 mm diam.; style white up to 11 mm long, finally exerted beyond the stamens. *Capsule* obovate, membranous 4 mm diam.; seeds ovate with very short terminal ridged aril.

DIAGNOSTIC CHARACTERS

The small racemose, campanulate flowers of *Lachenalia moniliformis* resemble those of several other species in the genus, particularly those of *L. juncifolia*, which also has terete leaves, but these are two in number, while in the former species they can number up to eight. Five other species produce many leaves, but the beaded structure of the leaves in *L. moniliformis* is quite unique in the genus, and the production of bulbils on long stout stolons is also of specific importance, while its seeds fall into the group with small ridged, terminal arils.

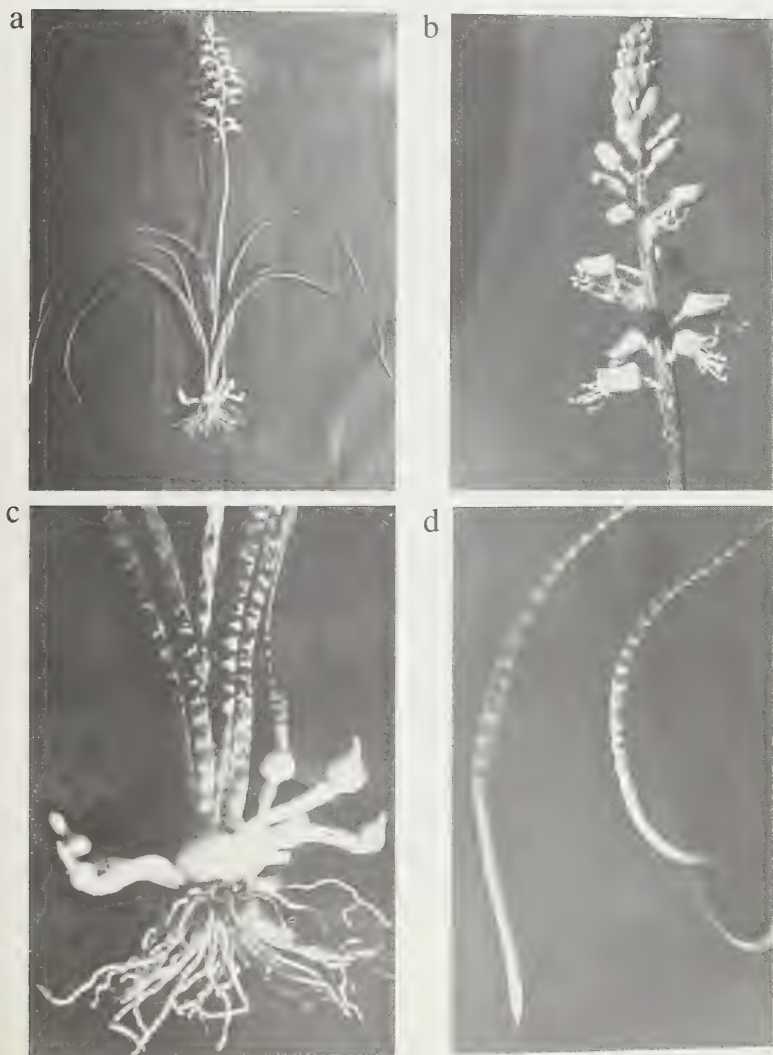


FIG. 11. a, b, c, d.

Lachenalia moniliformis: a. Whole plant; b. Inflorescence; c. Bulb with bulbils on stolons and banded leaf bases; d. Portions of two moniliform blades (Perry 795, holotype).



FIG. 12.

Lachenalia moniliformis: 1. Seed side view; 2. Seed from above; 3. Seed from below (Perry 795, holotype).

The original plant of this completely unknown species, was brought to the Compton Herbarium, on 22 September 1978, by Miss P. L. Perry of the Worcester Karoo Botanic Garden, and was collected by her at Lemoenpoort in the Worcester district. While the flowers were of a familiar type found in several species in the genus, the plant had five terete leaves. This many-leaved character is only shared by five other species, and in addition these are unique in having a structure reminiscent of a string of beads, which suggested the specific name.

As only one plant was known, a number of black and white photographs were taken, and the inflorescence and several leaves were pressed for the record. The plant flowered again on 5 Sept. 1979, this time producing eight leaves, which were much longer and more channelled above, near the base, and the beading had become less distinct.

Miss Perry visited the type locality again and was able to obtain a few seedlings to cultivate at Worcester. It was then decided to sacrifice the original plant to serve as a type. On lifting the bulb, it was found to be comparatively small, but it had produced a number of stout stolons from its base, which were terminated by well-developed bulbils, one of which had already developed a single leaf.

On 7 September 1979, after a very dry season in the area, the original site was visited again, and after a search in a somewhat sandy eroded area, a few plants were located in flower. Two of these plants were preserved as typical examples of wild specimens, and two were planted and cross-pollinated for seed.

SPECIMENS EXAMINED

CAPE PROVINCE—3319 (Worcester): Lemoenpoort (-CD), 22/9/1978, P. L. Perry 795 (NBG, iso.), cultivated at Worcester Karoo Garden; 5/9/1979, P. L. Perry (NBG, iso.), cultivated at Compton Herbarium; 6/9/1979, P. L. Perry 795 (NBG, holo.), wild specimens.

Lachenalia ameliae Barker, sp. nov.; habitu nano distinguitur.

Bulbus tunicis paucis, pallidis brunneis in collum productum. *Folia* unum vel duo, ovata vel lanceolata; lamina atroviridis, supra glabra vel pilis brevibus vel longis, interdum limitatus ad margines; pagina inferna marronina; basis amplexans, alba, subtiliter marronina punctata. *Inflorescentia* spicata. *Flores* cremicolores prope basin, palide flavescens tumoribus viridibus in segmentis externis; segmenta interiora longiora vel segmenta externa, eburnea lucentia; apices purpurei tincti. *Stamina* segmenta intima aequantia. *Semen* globosus, arillo porcato.

Type Material: Cape Province—3320 (Montagu): 5 km S of Bloutoring Station (-AD), 7/9/1979, C. Malan 90 (BOL, iso.; NBG, holo.; PRE, iso.).

Plant dwarf, 40–115 mm high. *Bulb* globose to depressed-globose, 8–15 mm diam.; covered with a few membranous light-brown tunics produced into a short neck. *Leaves* 1–2, blade 5–20 mm broad, ovate-acute to lanceolate, spreading to recurved, upper surface smooth or with few to many short to long hairs sometimes confined to the margin only, lower surface dark maroon, clasping base pale, finely spotted with magenta. *Inflorescence* spicate, 20–80 mm long, peduncle 10–60 mm long, bracts minute; flowers 12–14 mm long, sessile, spreading, narrow-urceolate, narrowed toward the base, tube cream, 4 mm long, outer segments 6 mm long, ovate-acute, cream at base shading to pale yellow above, with pale green gibbosities, and sometimes with a narrow maroon central stripe, inner segments up to 10 mm long, 3–4 mm broad, longer than the outer, the two upper overlapping, all cream to pale yellow with a central green keel, apices spreading to recurved, occasionally tinged with pale magenta at the apex as in the type collection, or with distinct dark purple tips; stamens finally as long as the inner segments, decurved; ovary 3 mm long, 2 mm diam., pale green, style cream, finally a little longer than the stamens. *Capsule* membranous, ovoid, 5 mm diam.; seeds ovoid with ridged aril of medium length.

DIAGNOSTIC CHARACTERS

Lachenalia ameliae is characterised by its dwarf habit, ovate to lanceolate leaves, dark green on upper surface with or without long or short hairs, the lower surface maroon. The inflorescence is spicate, the flowers narrow-urceolate, cream and yellow, the inner segments longer, the apices spreading to recurved, pale magenta to dark purple.

The earliest discovery of this species was made by Dr. R. Marloth at Zwartkoppies near Spes Bona in the Ceres district, in September 1921, and the specimens are preserved in the National Herbarium, Pretoria. This was followed by a collection by Professor R. H. Compton at Gansfontein in the

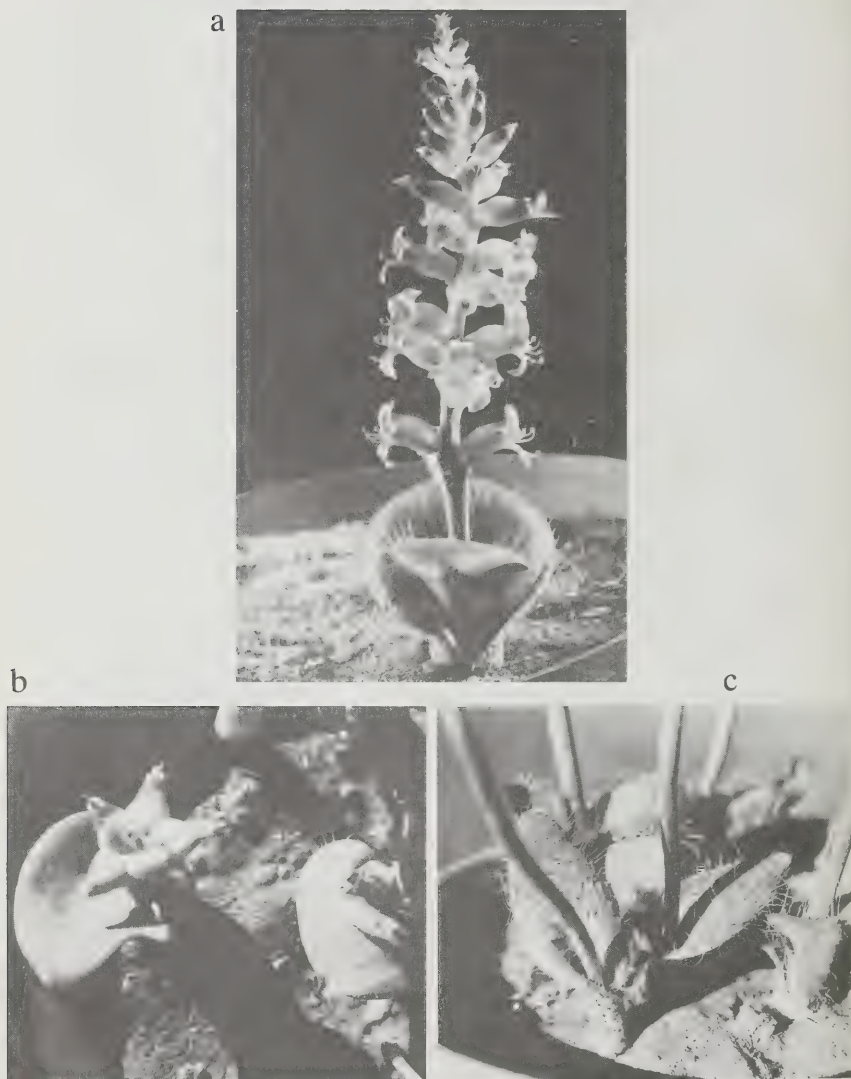


FIG. 13. a, b, c.

Lachenalia ameliae: a. Whole plant (Mauve, Oliver, Malan 206, PRE); b. Left plant with smooth leaf, right plant with few marginal hairs; c. Bases of plants with leaves with hairs on leaf surfaces (Malan 90, holotype, NBG).

Ceres District in August 1935, and another by G. J. Lewis and E. Esterhuyzen about ten miles from Montagu on the road to Ladismith in September 1935. These are both in the Bolus Herbarium collection. Most of the leaves of all these collections are incomplete, but they usually appear to be lanceolate, with a dense covering of short hairs on the upper surface, while the flowers have distinct dark purple tips to the inner segments.

More recent collections were made five kilometres south of Bloutoring Station, first by Mrs. A. A. Mauve, accompanied by I. Oliver and C. Malan, in September 1974, when three living specimens were made available for study with some ripe seeds. The same locality was visited in September 1979 by C. Malan and W. F. Barker, when it was possible to study the living plants in their natural habitat. They were found growing in red sandy clay on windswept flats, usually on humps with small karoo plants holding the soil. The shape of the leaves in this area proved to vary considerably, from broadly ovate to lanceolate, and the upper surface of the dark green blade was either quite smooth or the integument consisted of hairs of varying length and density covering the surface, or confined to the margins only.

None of the flowers examined in this locality had dark purple tips to the inner segments, but in some cases the extreme tips were tinged with magenta. The seeds available in both groups were similar in character, with small ridged arils.



FIG. 14.

Lachenalia ameliae: 1. Seed side view; 2. Seed from above; 3. Seed from below (Malan 90, holotype, NBG).

The species has been named in honour of Mrs. A. A. Mauve who brought the first living specimens from the type locality to my notice, and has contributed so much to our knowledge of the Liliaceae.

SPECIMENS EXAMINED

CAPE PROVINCE—3219 (Wupperthal): Zwartkoppies near spes Bona (-AD), Sept. 1921, Marloth 10479 (PRE); Gansfontein (-DD), 26/8/1935, Compton 5872 (BOL).
—3320 (Montagu): Between Bloutoring station and Withoogte, Touwsrivier (-AD), 9/1974, A. A. Mauve, I. Oliver & C. Malan 206 (NBG); 5 km S of Bloutoring Sta-

tion, 7/9/1979, *C. Malan 90* (BOL, iso.; NBG, holo.; PRE, iso.); About ten miles from Montagu along old road to Ladismith, Sept. 1935 (fruiting), *Lewis & Esterhuy-sen* (BOL).

ACKNOWLEDGEMENTS

I am much indebted to Dr. J. P. Rourke for the Latin translations of the diagnoses; to Miss P. L. Perry for bringing *L. moniliformis* to my notice, and for taking me to the type locality, and also to Miss C. Malan for arranging an expedition to the type locality of *L. ameliae*.

STUDIES IN ORCHIDACEAE FROM SOUTHERN AFRICA

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ABSTRACT

Habenaria lithophila Schltr. subsp. *mossii* Williamson subsp. nov. is described. *Nervilia humilis* Schltr., a new record for Southern Africa, is illustrated.

UITTREKSEL

STUDIES VAN ORCHIDACEAE VANAF SUIDER-AFRIKA

Habenaria lithophila Schltr. subsp. *mossii* Williamson subsp. nov. word beskryf. *Nervilia humilis* Schltr., 'n nuwe aantekening vir Suider-Afrika, word geïllustreer.

Key words: *Habenaria*, sp. nov., *Nervilia*, new record, Orchidaceae, South West Africa/Namibia.

Habenaria (sect. *Diphyllae*) ***lithophila*** Schltr. subsp. ***mossii*** Williamson, subsp. nov. a subspecie typica petalis lobis anticis et labello lobis lateralibus teretibus, calcari multo longiore distinguenda (**Fig. 1**).

Typus: South Africa, C. E. Moss 14412 (J, holo.).

An erect terrestrial herb 180-240 mm high. *Stem* slender to stout, straight, 2-5 mm in diameter, rising from an ellipsoid tuber up to 20 mm long and 15 mm in diameter. *Basal leaves* 2, opposite, prostrate, \pm orbicular, acute to cuspidate, longest up to 70 mm long and 60 mm broad; *cauline leaves* up to 23, erect, clasping stem, linear-lanceolate, acute, up to 15 mm long. *Inflorescence* densely up to 40-flowered, 70-90 mm long and 25 mm in diameter; flower bracts up to 17 mm long; flowers greenish, suberect; ovary with pedicel lightly curved, up to 15 mm long. *Intermediate sepal* erect, narrowly ovate, acute, ca. 7 mm long and 3 mm broad; laterals deflexed over ovary, longitudinally obliquely ovate to elliptical, subacute, ca. 8 mm long and 4 mm broad. *Petals* bipartite almost to the base; posterior lobe erect, adnate to the dorsal sepal, linear-ligulate, margin ciliolate, ca. 6 mm long and 1.2 mm broad; anterior lobe curved upwards horn-like, terete, densely ciliolate, acute, ca. 8 mm long and 0.6 mm in diameter. *Labellum* tripartite

Accepted for publication 2nd June, 1983.

with side lobes curved upwards and middle lobe curved forwards and downwards; middle lobe ligulate with ciliolate margins, ca. 8 mm long and 1,2 mm broad; side lobes terete, densely ciliolate, subacute, ca. 9 mm long and 0,8 mm in diameter; spur cylindrical, pendent to horizontal with a narrow base and slightly inflated apex, up to 23 mm long. *Anthers* erect, rounded, ca. 2 mm high, canals porrect to slightly curved upwards, ca. 1,8 mm long; stigmatic arms porrect with flat upper surface and rounded lower surface, apices obtuse, ca. 2 mm long; rostellum centre lobe triangular with obtuse apex curved backwards, ca. 1,2 mm high and much shorter than anther.

Habitat: open grassland on dolomite or in black sandy soil.

The new subspecies differs from the typical subspecies in that the anterior petal lobe and labellum side lobes are more or less terete and the spur is very much longer, measuring up to 24 mm.

This new species is named in honour of Prof. C. E. Moss who, in 1917, was appointed the first Professor of Botany at the University of the Witwatersrand. He collected extensively on the Witwatersrand (Gunn and Codd, 1981).

TRANSVAAL: Witwatersrand, Johannesburg, Thorntree Kloof, April 1927, C. E. Moss 14412 (J, holotype); 2 miles WNW of Krugersdorp, in grassland on dolomite, March 1954, A. O. D. Mogg J 29146 (J); W Rand, Sterkfontein, amongst "Olifantsklip" on the knoll, March 1954, H. B. Gilliland s.n. (J); Johannesburg, Waterval in black sandy soil, March 1957, J. E. Bartlett J 30224 (J).

Nervilia humilis Schltr. in Bot. Jb. 53: 551 (1915).

This new record was made by Mr. S. Venter in the company of Mr. D. Hardy in March 1977 while on a collecting trip to Swaziland. The plant colonies consisted of up to 30 plants growing in deep humus in shaded submontane woodland. The plant illustrated (Fig. 2) flowered in cultivation in the nursery of the Botanical Research Institute in February 1981.

SWAZILAND: Piggs Peak at $\pm 1\ 300$ m, col. March 1977, fl. Feb. 1981, Hardy and Venter 4186 (BOL, PRE).

ACKNOWLEDGEMENTS

The author is grateful to the curators of the Bolus Herbarium, University of Cape Town, the Kew Herbarium, Royal Botanic Gardens, Kew and the Moss Herbarium, University of the Witwatersrand, Johannesburg, for use of their facilities and the loan of material.

Thanks are also due to Dr. P. J. Cribb, Kew Herbarium, Royal Botanic Gardens, Kew, for advice and guidance, Messrs D. Hardy and S. Venter for material of *Nervilia humilis* and to Prof. E. A. Schelpe, Bolus Herbarium,

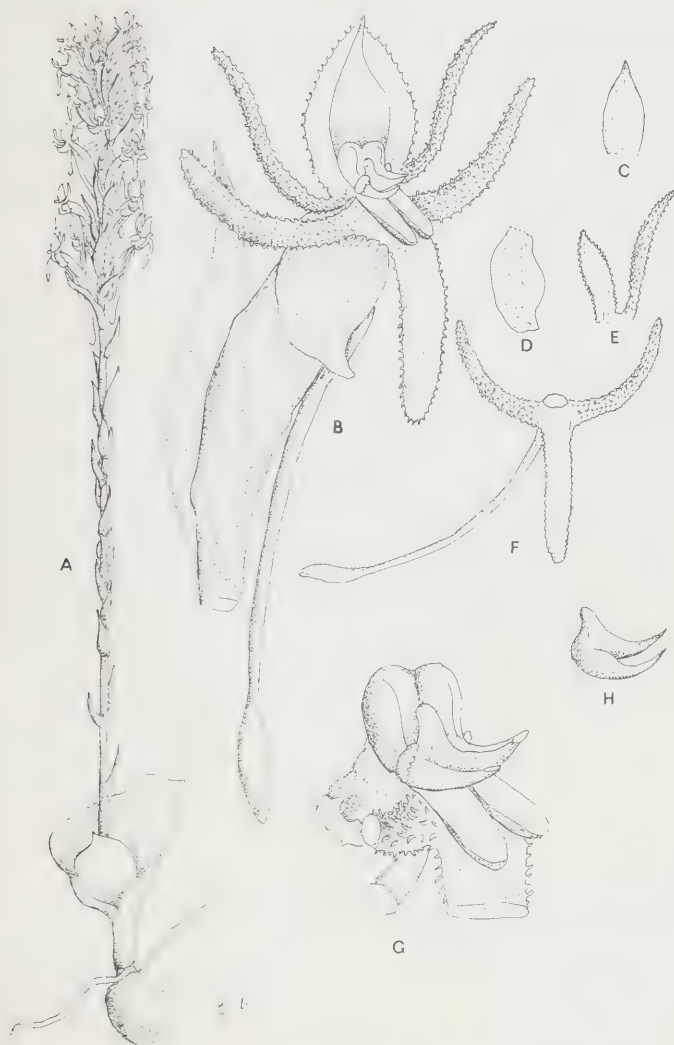


FIG. 1.

Habenaria lithophila subsp. *mossii*. A. habit, $\times \frac{2}{3}$; B. flower, $\times 4$; C. dorsal sepal, $\times 2$; D. lateral sepal, $\times 2$; E. petal, $\times 2$; F. labellum, $\times 2$; G. column, $\times 8$; H. rostellum, $\times 6$. All from A. O. D. Mogg J 29146 (J). All magnifications are approximate.

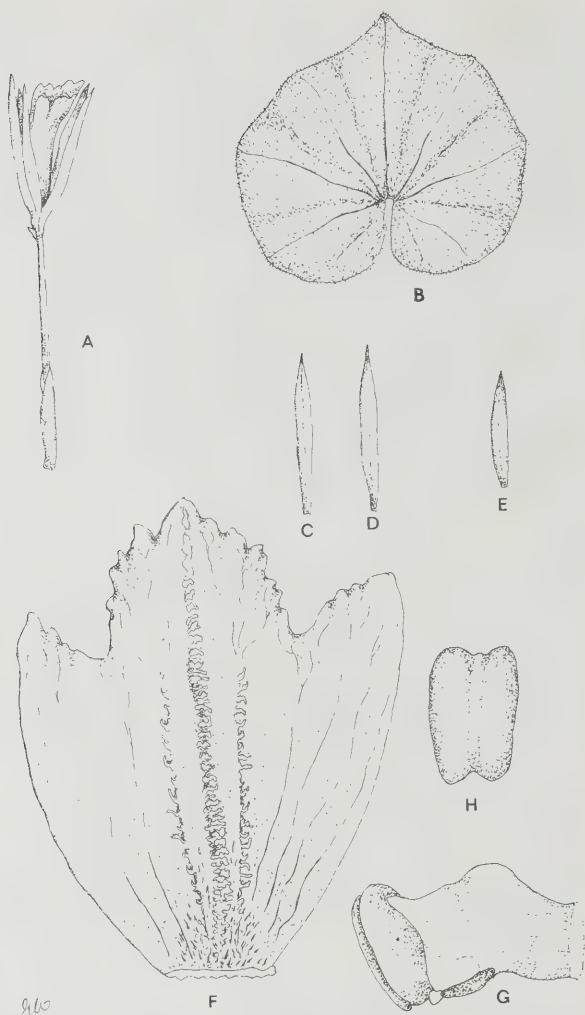


FIG. 2.

Nervilia humilis. A, habit, $\times 1$; B, leaf, $\times 1$; C, dorsal sepal, $\times 1$; D, lateral sepal, $\times 1$; E, petal, $\times 1$; F, lip flattened, $\times 6$; G, part of column, $\times 10$; H, anther cap, $\times 10$. From Hardy and Venter 4108 ex Hort B.R.I. All magnifications are approximate.

University of Cape Town, for guidance, advice and for reading the manuscript.

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A NEW SPECIES OF *ERIOSEMA* (FABACEAE) FROM THE EASTERN TRANSVAAL

CHARLES STIRTON*

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ABSTRACT

Eriosema naviculare C. H. Stirton, is described as new. This rare species is confined to the boundaries of the Lowveld and Lowveld Sour Bushveld vegetation types in the Pretoriuskop-Numbi region of the eastern Transvaal.

UITTREKSEL

'N NUWE *ERIOSEMA* (FABACEAE) SOORT VANAF OOS-TRANSVAAL

Eriosema naviculare C. H. Stirton word beskryf. Hierdie skaars soort is beperk tot die Laeveld en Laeveld-Suurbosveld plantegroei tipes in die Pretoriuskop-Numbi streek van Oos-Transvaal.

Key words: *Eriosema*, sp. nov., Fabaceae, eastern Transvaal.

Eriosema naviculare C. H. Stirton, sp. nov.; *E. saligno* E. Mey. proximum, sed foliis latioribus et floribus minoribus differt.

Planta perennis usque 500 mm alta. *Folia* trifoliolata. *Foliola* naviculiformia subtus coacta glandulosaque. *Inflorescentia* 30-40-floris. *Flores* 10-13 mm longi, bractea 6 mm longa, 1,5 mm lata, anguste lanceolata caduca. *Calyx* 6 mm longa, dentibus aequalibus breviter triangularibus pubescentibus, glandulis parvis albis interspersis. *Vexillum* orbiculare, flavum, signo nectario viridi, appendiculis bifidis auriculos carentibus. *Alae* flavae carinam pallidiflavam superantes. *Fructus* 20 mm longi, 11 mm lati, molliter alba pubescentes.

Type: TRANSVAAL—2531 (Komatipoort): 5 km from Hazyview to Numbi Gate (-AA), Stirton 9829 (PRE, holotype).

Erect perennial herb up to 500 mm tall arising from a clavate rootstock with 1-several lateral branches. *Stems* 1-5, minutely clothed in white hairs. *Stipules* 16 mm long, 4.5-5.0 mm wide, free, lanceolate-falcate, senescent before leaf expansion. *Leaves* trifoliolate, except for the 30-40 mm long,

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Accepted for publication 11th July, 1983.

20–28 mm wide, unifoliate leaves produced at the first two nodes; terminal leaflet 72–100 mm long, 41–63 mm wide, elliptic, symmetrical, stipellate; laterals smaller, asymmetrical with width ratio 1:2,3; all leaflets felt-like with raised veins below, covered in minute raised glands; strongly boat-shaped; petiolules 4–5 mm long, 3 mm wide; rhachis deeply channelled. *Inflorescence* 36–40-flowered, axillary, 210–240 mm long at maturity, 40 mm long when first flower opens. *Flowers* 10–13 mm long, each subtended by a 6 mm long, 1,5 mm wide, narrowly lanceolate, rapidly caducous bract. *Calyx* 6 mm long; tube 3 mm long; teeth equal, shortly triangular, 3 mm long, finely pubescent with small white glands interspersed. *Standard* 11 mm long, 8–9 mm wide, emarginate, orbicular, yellow with green nectar-guide, back finely pubescent with many small white glands; appendages fused, bifid, hooded, free from auricles; claw 5 mm long. *Wing petals* 10 mm long, 5 mm wide, yellow with a few hairs along the base; claw curved, 2 mm long. *Keel blades* 8 mm long, 3 mm wide, pale yellow, indented at base, with few hairs scattered along the lower margin, outer face with pale glands towards the apex; claw upcurving, 2 mm long. *Androecium* 8 mm long; vexillar stamen free, 7 mm long, geniculate. *Pistil* 7 mm long; ovary 3 mm long, white pubescent; style glabrous, height of curvature 2,25 mm, thickened at point of flexure; stigma minutely capitate. *Fruits* 20 mm long, 11 mm wide when green, softly white pubescent; beak straight, 1,5 mm long. *Seeds* unknown.

Considering the lack of access roads in the general area of distribution it is not surprising that this distinctive species has not been collected more often. *E. naviculare* can be confused with *E. salignum* E.Mey. (yellow-flowered form) but is readily separated from that species by its broad pubescent leaflets and much smaller flowers.

The specific epithet, “naviculare”, meaning boat-shaped, refers to the distinctive manner in which the leaves are borne from their axis.

SPECIMENS EXAMINED

TRANSVAAL—2531 (Komatipoort): 5 km from Hazyview to Numbi (-AA), Stirton 9829 (PRE); Shabani, van der Schijff 1394 (PRE, K); Pretoriuskop (-AB), van der Schijff 1498 (PRE, PRU, K), Acocks 16622 (K).

DISTRIBUTION AND BIOLOGY

Eriosema naviculare is restricted to grassveld in the Pretoriuskop–Numbi area. It has only been collected three times before. In all cases it was found in burnt veld. Flowering occurs from late October to early January.

As with all *Eriosema* in South Africa, nothing is known about the biology of this species. This genus should be investigated as all the South African species are densely glandular on most organs (against phytophagous insects)

and secondly have fleshy funicular remnants on the seed; the latter are certainly connected with ant dispersal of the explosively dispersed seed.

DIAGNOSTIC FEATURES

Erect herb; clavate rootstock; naviculate trifoliolate leaves; free, senescent lanceolate-falcate stipules; yellow flowers; caducous flower bract; equal and shortly triangular calyx teeth; standard with bifid hooded appendages free from the auricles and wing petals exceeding the keel blades.

ACKNOWLEDGEMENTS

I would like to thank Miss C. M. Wilmot-Dear for the Latin diagnosis; and Mrs. Jana Zantovska Stirton and Mr. B. Schrire for accompanying me in the field during my search for this species. Thanks also go to Dr. B. de Winter, Director, Botanical Research Institute, Pretoria, for arranging for a photograph to be taken of the type and for giving permission for it to be reproduced here.

BOOK REVIEWS

DICTIONARY OF CULTIVATED PLANTS AND THEIR REGIONS OF DIVERSITY: EXCLUDING MOST ORNAMENTALS, FOREST TREES AND LOWER PLANTS, by A. C. Zeven and J. M. J. de Wet, with pp. 263 and 110 maps. 2nd rev. ed. Wageningen: Centre for Agricultural Publishing and Documentation (Pudoc), 1982. Hard cover Dfl. 90,00 (R47 plus tax).

Reviewers of books featured in this *Journal* are asked to be constructive. In the present instance this is very difficult for as far as I can see its only commendable feature is overall appearance: size, pagination and format are in accordance with the best traditions of Pudoc. The binding seems tough and durable and is a great improvement on that of the original edition. There are a number of printing errors—*Sanseverinia* for *Sansevieria* and *Euphrobiaceae* for *Euphorbiaceae* are examples—and these are probably the result of slap-dash proofreading. But as far as the contents are concerned, for the life of me I cannot understand how this book achieved a second printing! I can only assume either that purchasers are extraordinarily ignorant of current concepts in taxonomy and phytogeography or that there is a chronic dearth of reference works in this field. And to add insult to injury, it has doubled in price.

The first edition was reviewed by the writer in 1976 [*Jl S. Afr. Bot.* 42 (2)] in which he described the general layout of contents. The work has now been enlarged to include about 2 300 species; unfortunately it has also incorporated a greater number of errors despite the comment of the senior author that mistakes and omissions have been rectified. The co-operation of a new co-author (Professor P. M. Zhukovsky died in 1975) does not seem to have benefited the present edition.

In the Preface it is stated that taxonomy is based primarily on Willis's dictionary (1966) and the Bailey Hortorium, *Hortus Third* (1976). Chromosome numbers are derived from Bolkhovskisch *et al.* (1969). Airy-Shaw revised Willis in 1973 and a far better conspectus of chromosome numbers was published under the auspices of the Missouri Botanical Garden in 1981. This explains the appallingly out-dated nomenclature and a plethora of inaccurate author citations; I counted 42 in the African Region section alone.

The drawings are hardly designed to aid taxonomy, for those on pages 99, 100, 111, 134, 136, 173 would not pass muster in a Botany I practical class; that of *Sorghum bicolor* looks like the sweeping-broom a certain Dutch admiral used to hoist to his mast-head. *Malus prunifolia* has its origin in Northern China and East Asia and yet is included in the Near Eastern Region. *Prunus bessyi* belongs to North America but its drawing is firmly set down in the Chinese-Japanese Region. This is very misleading. Many species are asterisked but it is left to the imagination to resolve the meaning of this symbolism. In fact it indicates that there is a related reference elsewhere in the book.

The aim of this work is to give the reader quick reference to the regions of diversity of cultivated plants and related wild species. If so, why is peach listed as having a secondary centre of distribution in California and not in Georgia? Why has lucerne not been included in the U.S.A.? A number of plants now widely cultivated in southern Africa are not included whereas some of dubious value receive "star" billing. As-

palathus linearis and *Cyclopia genestoides* are not mentioned and the taxonomy of the buchus is hopelessly inaccurate.

Distribution maps do not inspire confidence and the snippets of data given in the text are inadequate. *Dioscorea hirtiflora* for example, occurs in dense forests as well as "Savanna" and *Oxytenanthera abyssinica* extends to the limits of the tropical zone. The maps depicting Central American and Mexican Region and North American Region exclude the West Coast of the U.S.A. completely. Presumably the authors are waiting for a cataclysmic shift of the San Andreas Fault to raft California out to sea, whereupon it can be treated as an island ecosystem!

I apologise to Pudoc but not to the authors for this scathing review. They ought really to have done their homework more thoroughly.

O. KERFOOT

THE STUDY OF PLANT STRUCTURE: PRINCIPLES AND SELECTED METHODS, by T. P. O'Brien and M. E. McCully, with pp. x + 248. Melbourne: Termarcaphi Pty Ltd, 1981. Distributed outside Australia by Blackwell Scientific Publications, approx. US \$32,00. ISBN 0 9594 174 0 0.

Books on plant microtechnique do not appear frequently. All anatomists and morphologists—in fact all botanists seriously interested in plant structure—are familiar with Johansen's classic *Plant Microtechnique* (1940) and Sass' *Botanical Microtechnique* (3rd edition, 1958). These two books were followed by Jensen's *Botanical Histochemistry* (1962), a pioneer in its field but now crying out for revision and updating (an immense task!), as well as *Botanical Microtechnique and Cytochemistry* by Berlyn and Miksche (1976), purportedly the successor to the Sass book, but somewhat heavy and disappointing.

One of the outstanding botanical papers of 1968 was that by N. Feder and T. P. O'Brien which appeared in the *American Journal of Botany* (55: 123–142) under the title "Plant microtechnique: some principles and new methods". This paper introduced the revolution which subsequently occurred in plant microtechnique by providing convincing evidence that there were available methods far superior to the classic coagulative fixative–paraffin wax embedment techniques.

Now O'Brien (Monash University, Australia) and Margaret McCully (Carleton University, Canada) have, in the book under review, produced a worthy successor to Johansen's, Sass' and Jensen's books. *The Study of Plant Structure* will be welcomed by the microtome for, in addition to many novel methods, there are a host of practical tips and an excellent list of references.

The book is organised into six chapters. The first is a short presentation of physical principles as they apply mainly to the perception of structure, while the second considers methods of microscopy and includes valuable information on fluorescence, a hitherto much neglected aspect of botanical microscopical procedure. Chapters 3 and 4, respectively, deal with morphological and anatomical methods. Chapter 5 is on photomicrography. Finally, Chapter 6, the practical heart of the book, encompasses what the authors refer to as *Formulary*. As the term implies, this is a glossary of protocols involving everything from replicas, whole mounts and macerates to fixatives, embedment, sectioning and staining. The book is concluded with 11 appendices and a long list of references, but—most unfortunately—with no index. This omission, together with a weak binding, is the book's most serious defect.

The authors might have argued that the more than five pages of contents negates the preparation of an index, but finding one's way around can be quite frustrating. It is not made any easier by the bureaucratic blur of digits. Example: Negative staining is listed as 6.15.13.6 under 6.15.13—Staining Methods for Electron Microscopy, and found on p. 6.102. There are also other—but minor—irritations such as a large number of typographical errors (example: James and Jape instead of James and Jope) and the mentioning of obviously interesting and specific methods (example: fluorescent staining of DNA by 4'6-diamidino-2-phenylindole) without giving the full procedures.

The authors have produced a mine of well-documented and pertinent information, ranging from careful, stepwise procedures such as, for example, the re-purification of glutaraldehyde to valuable hints on the physical manipulation of materials, techniques and instruments. Their explanations of the principles of microscopy, fixation and staining are uncomplicated and lucid. The history and development of plant microtechnique is also adequately covered by their extensive coverage of the relevant literature.

If ever so slight an impression might be gained that O'Brien and McCully are actually writing for O'Brien and McCully, it should be seen against the background of the vast collective microtechnical experience of both of these pioneering – and, it should be added, excellent—investigators. *The Study of Plant Structure* is a highly recommendable compendium.

CHRIS H. BORNMAN

MOLECULAR BIOLOGY OF PLANT TUMOURS, edited by G. Kahl and J. S. Schell, with pp. xxiv + 615. New York, London, Paris, San Diego, San Francisco, São Paulo, Sydney, Tokyo, London: Academic Press, 1982. US\$69.50. ISBN 0 12 394380 9.

With the flush of current interest and activity in plant molecular genetical engineering, a book on plant tumours was bound to be among those that have started to appear. Some plant tumours, namely, are associated with two species of *Agrobacterium*: *tumefaciens* and *rhizogenes*. These bacteria, the respective causative agents of stem tumours and hairy root disease, contain corresponding tumour-inducing (Ti) and hairy root-inducing (Ri) plasmids. These plasmids are regarded as potentially the most important vectors for the eventual transformation of plants via the transfer of foreign DNA into that of the host plant's genome.

The book under review is an impressive volume, comprising 24 chapters contributed to by no less than 51 authors. It is divided into three parts: (1) abnormal plant growth, (2) crown gall tumours, and (3) potential vectors for genetic engineering in agriculture. In Part 1 there are two especially highly informative contributions, one on habituation or anergisation and the other on the physiological aspects of genetic tumour formation in interspecies hybrids. There is also a contribution on insect galls with major emphasis on galls of the Cecidomyiidae. In Part 2 the doyen of the crown gall, Armin Braun, gives a historical account of the problem. There follow contributions by persons who have been and are very actively engaged in Ti plasmid research: Van Montagu, Schell, Chilton, Schilperoort, Tempé, and others. Finally, in Part 3, other potential vectors such as cauliflower mosaic virus and plasmids of *Rhizobium* are also considered.

This book is timely, coming as it does at a period when "molecular plant genetic engineering" has become a catch phrase, but yet underscoring the point that man is able to learn his lessons from Nature. As Schell likes to point out, Nature, in the form of *Agrobacterium tumefaciens*, has set a perfect example of how genes are engineered, and moved, from micro- to macro-organism. Applying these lessons, a number of laboratories (such as Ghent, Versailles, Leiden, Cetus-Berkeley) have shown that the integration of foreign DNA into the plant cell genome is not only possible, but that its transmittance through meiosis to subsequent plant generations is feasible.

Although comprised of many chapters by more than twice that many authors, the book is well edited and supplied with an extensive index. The papers on the whole are eminently readable and well-illustrated, and should serve as valuable sources of reference. It is not only the molecular biologist who will benefit by this book, but tissue culturalists generally, regardless of whether their primary interest is genetics, biochemistry or plant physiology.

CHRIS H. BORNMAN

PHYSIOLOGICAL PLANT ECOLOGY: II. WATER RELATIONS AND CARBON ASSIMILATION, edited by O. L. Lange, P. S. Nobel, C. B. Osmond and H. Ziegler, with pp. xi + 747 and 153 figures. New York, Heidelberg, Berlin: Springer-Verlag, 1982. Volume 12 Part B in the New Series "Encyclopedia of Plant Ecology". DM 288, approx. US\$120,10. ISBN 3 540 10906 4.

This is the second in the four-part series on physiological plant ecology. It is a large book (747 pages) made up of 18 chapters plus an Introduction, an author index, a taxonomic index and a subject index (which is comprehensive and very useful).

The title gives equal emphasis to water relations and carbon assimilation, and although the two are inextricably linked in an ecological sense (as emphasised by the authors in their Introduction), there is in fact far more weight given to water relations. Fourteen of the chapters are concerned primarily or exclusively with water, and only four with carbon assimilation.

The book begins with a useful overview of water in the soil-plant-atmosphere continuum. The next four chapters deal with water status, uptake, movement and storage in plants, followed by two chapters on water loss (via plant surfaces and via stomata). All of these chapters are detailed, up-to-date and of a high standard. There is then a chapter which reviews the various mathematical models of water loss. The chapter itself is descriptive with virtually no mathematics of its own.

The following three chapters provide a thorough, physiological and physical account of plant water stress. They provide a most useful and interesting account of this subject.

Following two chapters on germination (of seeds and spores) and one on flooding, the final four chapters deal with photosynthesis and carbon-water relations. The chapter by Osmond, Winter and Ziegler on the functional significance of different pathways of CO₂ fixation in photosynthesis is of particular note. The first half of the chapter is a well-presented review of the fundamental biochemical basis of the three photosynthetic CO₂ fixation pathways. It is followed by sections on the physiological context and the ecological context, and the chapter is recommended reading for all who are interested in the physiological basis of plant ecology. The final chapter, by E.-D. Schulze, on plant life forms and their carbon, water and nutrient relations, is

also a very useful review of the physiological basis for different forms and growth habits of plants.

Technically the book is well produced. There are virtually no typographical errors. Figures and tables are clear and the cross-referencing and common style suggest careful editing. Considering today's book prices, the cost is not outrageous (a mere \$120), but it is a pity that it will be beyond the means of most individuals, since the book deserves to be in the personal library of all plant ecologists. It is a must for all libraries concerned with botany, ecology and agriculture.

B. H. WALKER

ADVANCES IN RESEARCH AND TECHNOLOGY OF SEEDS: PART 6, edited by J. R. Thomson, with pp. 124. Wageningen: Centre for Agricultural Publishing and Documentation (Pudoc), 1981. Dfl. 36,00. ISBN 90-220-0786-3.

This is again a worthwhile contribution in which recent advances in four pertinent topics in the field of the physiology of seed development and germination are reviewed. The following topics are covered: Ecological aspects of seed germination (P. A. Thompson); Physiological and biochemical events in seed development (Daphne J. Osborne); Changes in seed composition during germination (J. C. Slaughter); and Germination of seeds (A. Lovato).

Although all four reviews are valuable in assisting the seed scientist to keep informed of new developments, the review by Thompson is an approach from a different angle and particularly interesting subjects such as maintenance of plant population, germination strategies and environment and phenotypic plasticity of germination responses in relation to geographical distribution are discussed.

Advances in Research and Technology of Seeds is primarily intended for seed research workers and seed technologists. Apart from the seed specialist, however, this volume would also be of special interest to plant ecologists in South Africa.

Plant names and subject matter are well indexed.

J. G. C. SMALL

ADVANCES IN RESEARCH AND TECHNOLOGY OF SEEDS: PART 7, edited by J. R. Thomson, with pp. 140. Wageningen: Centre for Agricultural Publishing and Documentation (Pudoc), 1982. Dfl. 36,00. ISBN 90-220-0802-9.

This volume contains four reviews primarily covering papers published after 1977.

Weed seed investigations by R. J. Chancellor reviews dormancy, periodicity of germination, seeds in the soil, survival of buried seed and seedling emergence. The possibilities and need for further investigations on the use of chemicals for breaking weed seed dormancy as an effective control measure are clearly shown.

Effects of radiation on seeds is aptly reviewed by A. D. McKelvie. In addition to ionising radiation effects, in which field most papers were published, the review mentions a few papers on microwaves, ultrasound and magnetic fields.

The shift in research emphasis from mutation induction to stimulation of growth and yield by radiation is interesting.

The review by D. L. Smith on seed development and structure emphasises morphology. This is welcomed in a science dominated by physiology and biochemistry. Seed identification remains a problem for seed analysts and it is of interest to note the possible use of the computer as a tool in seed identification.

Research on environmental and genetic factors affecting tree and shrub seeds is reviewed by B. S. P. Wang, J. S. Pitel and D. P. Webb.

Although papers on dormancy dominate this review, other interesting topics such as effect of pesticides and seed mass on germination, seed dispersion and seed losses due to insects, rodents and disease, are covered.

This volume, with a good subject index, should appeal to a wide range of plant research scientists including geneticists, foresters and ecologists.

J. G. C. SMALL

ANNOUNCEMENT

It is a great pleasure to announce the founding of the International Association for Landscape Ecology. The objectives of this organisation are to enhance communication among scientists, planners and managers in landscape ecology, and to promote the development of knowledge in this field and its dissemination and application.

The landscape concept deals with areas on a scale which may contain many relatively homogeneous ecosystems, or landscape elements, which invariably differ in the degree of human activity or impact associated with them. Landscape ecology, therefore, studies the structure, function and development of landscapes. Structure in this context may refer to the spatial dimension and distribution of landscape elements; function to the flow of energy, mineral nutrients and species among these elements, and development to the change in the landscape as a whole through time.

An interest in the development of concepts in this field, or the application of such concepts, forms the kernel of the International Association, whose members include, *inter alia*, ecologists, geographers, planners, landscape architects, foresters, wildlife biologists, land managers, urban and regional designers and environmental scientists. Landscape ecology is, of course, a formal discipline in a number of European countries.

Anyone who has an interest in landscape ecology is invited to send their name and address to:—

O. Kerfoot
Regional Representative for IALE,
Department of Botany,
University of the Witwatersrand,
1 Jan Smuts Avenue,
JOHANNESBURG 2001,
R.S.A.

You will receive the first issue of the IALE Bulletin and other announcements once you are on the mailing list.

JOURNAL OF SOUTH AFRICAN BOTANY

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1983

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